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GEODETIC SURVEY OF SOUTH AFRICA.—Vol. V.

REPORTS

ON

THE GEODETIC SURVEY

OF THE

TRANSVAAL AND ORANGE RIVER COLONY,

EXECUTED BY

COLONEL SIR W. G. MORRIS, K.C.M.G., C.B.,
(LATE ROYAL ENGINEERS),
Superintendent of the Survey,

S. A. OBSERVATORY,
13 SEP. 1908
KODAIKANAL.

And of its connection, by Captain H. W. Gordon, R.E., with the Geodetic Survey of Southern Rhodesia,

WITH

A PREFACE AND INTRODUCTION

BY

SIR DAVID GILL, K.C.B., LL.D., D.Sc., F.R.S., &c.,
Scientific Adviser to the Survey, formerly H.M. Astronomer at the Cape of Good Hope.

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PREFACE

THIS work contains an account of the operations in the Transvaal and Orange River Colony which completes the Geodetic Survey of British Africa South of the Limpopo, and of the connection of that work with the previously existing Geodetic Triangulation of Rhodesia. This latter connection, although not strictly a part of the Geodetic Survey of the Transvaal and Orange River Colony, finds its place in the present volume because it brings into evidence the mutual agreement of these independent surveys. (*See* Appendix, p. xxix.)

My own part of the work has been that of Scientific Adviser: the history of the inception and plan of the work will be found in the Introduction which I have written.

The survey has been carried out under Colonel Sir William Morris, K.C.M.G., C.B., its responsible Superintendent; the account of its execution is from his pen, and is supplemented by the reports of his subordinate officers.

The reader who may have in future to organise similar work in other parts of the world will do well to study Sir William Morris' Report (pp. 3–56), which embraces the results of his unique experience not only as a Superintendent of Geodetic Field Work on a large scale, but as a practical worker in the field. The care and forethought bestowed by him on all details of administration and the example of his untiring personal energy have been chief factors in the smooth working and complete success of the whole operation.

Mr. W. B. Robinson has rendered invaluable service as head of the Computing Office, and his Report (pp. 57—201) is the best proof of his thoroughness and capacity. He has brought to bear upon the work the experience gained by him as an astronomical computer at the Royal Observatory, Cape of Good Hope, as a Geodetic computer in connection with the Survey of Cape Colony and Natal, and in field and office work connected with the Survey of Rhodesia.

Mr. Alexander Simms contributes the Report on the Measurement of Base-lines. He had previous experience in use of the Jäderin apparatus in preliminary comparisons at the Royal Observatory, Cape of Good Hope, and in the measurement of two base-lines in Southern Rhodesia, when he was in charge of the Geodetic Survey of that country. (Geodetic Survey of South Africa, vol. iii.) It is to his painstaking care in training the base-measuring party that the marked success of the base-measurements is due.

The Reports of Messrs. Cochrane, Gummer, and Banks on the Subsidiary Processes of Base-measurements (viz., levelling, aligning, and adjusting the scales), are chiefly valuable, as they refer to the methods actually employed, but may be of less interest in future, because in the more recent forms of the apparatus, as developed by Guillaume, improved facilities are given for these processes.

It also seems probable that the costly and laborious process of comparison with "ground standards" (involving as it does the transport of a complete bar-apparatus, with its "camels," tripods, microscopes, &c.), can in future be avoided by simply comparing the wires used for measurement directly with modern standard *invar* spare wires, kept in reserve on drums, the latter wires being compared from time to time at the International Bureau at Sèvres (S. et O.), or at the National Physical Laboratory, Teddington.

This great simplification becomes admissible on account of the improved methods of annealing, and other treatment of *invar* wires, which have been developed at the International Bureau of Weights and Measures at Sèvres. By this treatment such a condition of molecular stability is insured that the constancy in length of modern Standard wires can be relied upon within 1 : 1,000,000 per annum. Wires of this proved stability were not available when the present work was undertaken.

The small probable errors of the observed horizontal angles:

Viz.: ± 0″·30 when measured with 8 changes of zero,
± 0″·39 „ „ 4 „

testify to the care and skill of Mr. A. Simms and Captains Gordon and Ley in their use of the Repsoid theodolites.

It should, perhaps, be mentioned here that the adjustment of the whole system of the new triangulation to geometrical consistency with the base lines, and with the previously closed gridiron system of triangles in Cape Colony, has, of necessity, produced small changes from the previously published co-ordinates and bearings of those points which occur in the chain of triangles between Groot Tafel Berg and Kimberley, and in the chain of triangles between Port Elizabeth and Newcastle (Natal). It is therefore necessary, when any subsidiary triangulation has been connected with any point of which the co-ordinates are given in this volume (pp. 362–451), to adopt the data of this volume to the exclusion of the data of Volume I. Also, when the results of Dr. Rubin's triangulation north of the Zambesi have been computed, it will be necessary to correct (*see* p. xxix) the whole system of triangulation north of the Limpopo, so as to give geodetic continuity to the system, and this will involve small corrections to the geodetic latitudes, longitudes, and bearings given in Volume III.

The extension of the arc of meridian from the Zambesi northwards, to within 70 miles of Lake Tanganyika, was carried out under the superintendence of Dr. Rubin between the latter part of 1903 and June, 1906. The triangulation is shown in the General Map; an account of the work and its results will be published in a subsequent volume.

DAVID GILL.

INTRODUCTION.

THE history of accurate Survey in South Africa begins when the Abbe de la Caille, in the year 1752, measured a short arc of meridian $1\frac{1}{4}$ degrees in length from Cape Town northwards. Nearly a century later, Mr. (afterwards Sir Thomas) Maclear (1841 to 1848) extended la Caille's arc southwards to Cape Point, and northwards to Koeburg (latitude 29° 44′).

La Caille, 1752.

Sir Thos. Maclear, 1841-48.

Nothing further was done either in the way of Geodetic Survey, or even of extensive accurate triangulation, until 1859, when a triangulation of the S.E. part of the Colony was undertaken, partly to furnish the Hydrographic Department of the Admiralty with accurate reference points by which to correct the then very inaccurate and defective state of the charts of the coast, and partly to afford means of better connecting the detached farm-surveys in that part of the Colony. The work was entrusted to Captain Bailey, R.E., and was executed under his direction, in 1859–62, at the expense of the Colony.

Captain Bailey, R.E., 1859-62.

Here progress in accurate and connected Survey ceased, farms being bought and sold on detached Surveys—often of the most primitive character—and although much excellent detached triangulation was done by the better trained and more painstaking of the Government Land Surveyors, their work had no well defined scale or orientation, and in most cases means were wanting for defining the position of local triangulations on the general map of the country. The result, of course, was that when these detached surveys were plotted in a general map they overlapped or left gaps, as the case might be, beacons were shifted, government ground was enclosed by private owners, and constant law-suits between proprietors occurred.

Soon after my appointment as Astronomer at the Cape, in 1879, I began to study the general question of the Survey of the Country. The need of improved methods was great, and the traditions of my office appeared not only to justify but to demand that some portion of my time and attention should be devoted to this work. There existed not only the great economic need for improved methods of Survey, but from the scientific point of view the need was no less pressing. Beyond Maclear's short Arc of Meridian there existed no Survey in the Southern Hemisphere of sufficient accuracy and extent to be of value for Geodetic purpose.

Accordingly I prepared plans for a gridiron system of chains of principal triangulation extending over the Cape Colony, Natal, the Transvaal, and the Orange Free State, and entered into correspondence with the Governments of these Colonies and States with the view of obtaining their joint co-operation for execution of the scheme.

Preparation of general plans for a geodetic survey of South Africa.

Sir Bartle Frere was then Governor of Cape Colony and High Commissioner for South Africa. From his experience of Indian administration he thoroughly realised the true economy of having all land surveys based upon a Principal Triangulation of such accuracy that its results might be considered definitive for all future time, and he gave his utmost support to my proposals.

But the political and financial situation in South Africa at the time rendered it impossible to make immediate progress. The despatches, correspondence, and papers on the subject were, however, laid upon the table of the House of Assembly at the Cape in 1880 (printed in a Special Blue Book)[1], and Ministers agreed to further consider the question in the following Session.

Co-operation between the Cape Colony and Natal.

The history of subsequent negotiations is summarised in the Introduction to Volume I of the Geodetic Survey of South Africa,[2] and need not be repeated. It is sufficient to state here that I finally succeeded in arranging an agreement between the Governments of the Cape Colony and Natal to carry out my original plan of triangulation as a joint work so far as these Colonies were concerned.

A detachment of Royal Engineers, consisting of Captain Morris, R.E. (now Colonel Sir William Morris, K.C.M.G., C.B.), Lieutenant Laffan, R.E. (now Lieut.-Colonel Laffan, C.M.G.), with fourteen non-commissioned officers and men, finally reached Durban in June, 1883, and work was at once commenced by laying out and measuring a base-line in Natal.

The subsequent operations in Natal and the Cape Colony are described in detail in Vol. I. of the Geodetic Survey of South Africa[2], and the reader may gather the general plan of the operations from the attached map of the existing triangulation of South Africa.

Re-reduction of the Surveys of Bailey and Fourcade.

The new Geodetic Survey described in the volume in question contained a chain of triangulation which passed through and included the main points of Bailey's Survey. The original report of Captain Bailey's triangulation, from Cape Town along the south coast of Cape Colony and British Kaffraria, was printed and presented to the Parliament of Cape Colony in 1863. The original observations were fairly good, but the printed Report is full of typographical errors, and the results are often geometrically inconsistent. Most of the original papers were lost by the foundering of the coasting steamer "Waldensian," but several copies of most of the original documents exist. A complete rediscussion of the whole work was therefore necessary, and I desired to include in this discussion any good connected triangulation that might be available in the Colony; but beyond a large area in the Knysna district, which had been well triangulated by Mr. Fourcade of the Forestry Department, I was unable to obtain access to any suitable work of the kind. The whole work was completely reduced to geometrical consistency with the Geodetic Survey, and the results, published in 1901 as Vol. II. of the Geodetic

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[1] Despatches and papers relative to proposed continuation of the Trigonometrical Survey of the Cape Colony in connection with adjacent territories. Printed by order of the House of Assembly. Cape Town, 1880.

[2] Report on the Geodetic Survey of South Africa, executed by Lieut.-Colonel Morris, R.E., C.M.G., in the years 1883-92, under the direction of David Gill, Her Majesty's Astronomer at the Cape, together with a re-discussion of the Survey executed by Sir Thomas Maclear, F.R.S., in the years 1841-48, by David Gill, LL.D., F.R.S., etc. Presented to both Houses of Parliament by command of His Excellency the Governor. Cape Town, 1896.

Survey of South Africa.[3] In this way all the available survey operations were brought into harmony.

Bosman's Survey.

In my original plan for the Geodetic Survey of South Africa there was indicated a chain of triangles extending from the north of Maclear's Arc, or rather from Port Nolloth, along the Orange River to Kimberley. It was subsequently found that the arid character of the country would have rendered this operation more costly than would have been compatible with its importance in other respects, but the requisite control has been provided for by a remarkably accurate triangulation in Bechuanaland, executed by Mr. Bosman (now Geodetic Officer of the Survey Department of Cape Colony), extending from Vryburg westwards to the 20th Meridian, and northwards along the 20th Meridian to Reitfontein (lat. 26° 47′).

Connection of Bosman's Survey with Geodetic gridiron of triangulation by Alston in 1898–99.

Bosman's Arc was connected in 1898, at its eastern extremity, with the geodetic points near Kimberley by an excellent triangulation made by Mr. Alston, Government Surveyor, employing a 10-inch Repsoid theodolite, similar to that used in the Geodetic Survey. The same officer, with the same instrument, in 1899, connected the northern extremity of Maclear's Arc with the western end of Bosman's chain of triangulation. Mr. Alston's connecting chains are shown for the sake of distinction in dotted lines in the general map.

The Anglo-German Boundary Survey, between British Bechuanaland and German S.W.

In 1896 I went on a mission to Berlin, at the request of H.M. Colonial Office, to discuss with the authorities there the best means of defining the boundary (along the 20th Meridian) between British Bechuanaland and German South West Africa. An arrangement for this purpose was submitted by Baron von Danckelman (the Geographical expert attached to the Foreign Office at Berlin) and myself, and it was finally approved on the 1st January, 1898 by both Governments concerned.

The Boundary Commissioners, Major Laffan (now Lieut.-Colonel Laffan, C.M.G.) representing Great Britain, and Lieutenant Wettstein, representing Germany, met at Reitfontein (the northern point of Bosman's Survey on the 20th Meridian) on the 18th November, 1898, and commenced at once to carry out the triangulation from Reitfontein along the Meridian of 20° E. Longitude to the point of its intersection by the 18th parallel of South Latitude, and along that parallel to its intersection by the Meridian of 21° E. Longitude.

A full account of the subsequent operations was prepared by me in 1905, and that Report, together with a translation, in German, by Baron von Danckelman, was published at Berlin in 1906[4].

The plan of the triangulation is sufficiently shown for present purposes in the General Map.

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[3] Cape of Good Hope. Geodetic Survey of South Africa, Vol. II. Report on a rediscussion of Bailey's and Fourcade's Surveys and their reduction to the system of the Geodetic Survey by Sir David Gill, K.C.B., LL.D., F.R.S., &c., His Majesty's Astronomer at the Cape. Presented to both Houses of Parliament by command of His Excellency the Governor. W. A. Richards and Son, Government Printers. 1901.

[4] Report of the Boundary Survey between British Bechuanaland and German S.W. Africa, executed by Lieut.-Colonel Laffan, R.E., Commissioner on behalf of Great Britain; and Lieut. Wettstein, and later by Ober-Lieut. Doering, Commissioners on behalf of Germany, under the direction of Sir David Gill, K.C.B., LL.D., F.R.S., &c., His Majesty's Astronomer at the Cape. Berlin, 1906. Printed by E. S. Mittler and Sons, Kochstrasse 68.

Original proposal for an arc of Meridian from the Cape to Cairo.

In advocating the commencement of a Geodetic Survey of South Africa, the following passage occurs in my Report, addressed to Sir Bartle Frere, dated 26th September, 1879.[1]

> The proposed Meridian Series along the 30th Meridian of East Longitude I look upon as the first step in a chain of triangles which ultimately will connect Natal with the Mediterranean and Alexandria. This is no exaggerated statement. The survey of Egypt along the Nile must come, as a matter of necessity, in course of time. This chain of triangles could be carried without difficulty along the Nile to Lakes Albert and Victoria Nyanza. Thence the chain would have to be connected with Lake Tanganyika and southwards to meet the Natal and Transvaal triangles at the Limpopo. We know now that the country presents no insuperable difficulties, and I have no doubt that the work will ultimately be done. Perhaps the present generation will not live to see its completion, but it is a great work that I believe will yet be performed if kept steadily in view.

Nothing is easier than to suggest such projects; the thing is to execute them.

At pp. 157 and 158 of the Report on the Geodetic Survey of Cape Colony and Natal[2] I have written :—

> *Looking forward to the practical and possible progress of Geodesy the question may be asked, 'Should not the progress made in Geodetic Survey in South Africa be regarded as the first step in a chain of triangulation which, approximately traversing the 30th Meridian of East Longitude shall extend continuously to the mouth of the Nile?' But this is not all. By an additional chain of triangles from Egypt along the coast of the Levant and through the islands of Greece, the African arc might be connected with the existing triangulation of Greece and the latter is already connected with Struve's great arc of meridian which terminates at the North Cape in latitude 70° north.*

In pursuance of these aspirations I had in 1895 endeavoured to interest the late Cecil Rhodes in this great enterprise. He expressed the utmost sympathy with it, and promised that when certain roads, bridges and railways, which were urgently wanted for the development of the country, had been completed, he would make provision for the proposed survey.

Geodetic Survey of Southern Rhodesia.

Early in the year 1897 I had an opportunity of discussing with Earl Grey, who was then Administrator of Rhodesia, the desirability of systematic survey as a first essential to a sound system of land tenure in a new country, and I endeavoured to prove to him the impossibility of surveying a country or of granting indisputable titles to land by surveys made in a patchwork way. At his request I wrote a letter addressed to his lordship, embracing the arguments in question, which will be found at pp. 1—3 of Volume III. of the Geodetic Survey of South Africa.[5]

Further correspondence ensued, and finally, on the 19th of August, 1897, the work was officially placed under my own direction. In planning the work it was necessary to keep two leading points in mind :—

1. To establish a chain of triangulation from Bulawayo eastwards towards Selukwe and Gwelo, covering the most populated and important part of the country.

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[1] *See* footnote p. vi.

[2] *See* footnote p. vi.

[5] Rhodesia—Geodetic Survey of South Africa, Vol. III. Report on the Geodetic Survey of part of Southern Rhodesia, executed by Mr. Alexander Simms, under the direction of Sir David Gill, K.C.B., D.Sc., LL.D., F.R.S., &c., His Majesty's Astronomer at the Cape.
Cape Times Limited, Printers, Cape Town, 1905.

2. To extend the chain northwards and southwards along the 30th Meridian, in order that the work might form part of the arc which it is proposed, if possible, to extend along that meridian from the south of Natal to the Mediterranean.

Mr. Rhodes, however, insisted that the chain of triangulation, before being carried southwards, should be first extended northwards to Lake Tanganyika. "I have promised to find you funds to carry it there, and if you can induce the Transvaal to come and meet me at the Limpopo, it will be then time to carry it southwards and meet them."

A full account is given of the operations and their results in Vol. III. already quoted.[5] It is sufficient to state that the conditions for work, especially northwards from Gwelo to the Zambesi, were very trying, and progress was slow and costly owing to the fact that trigonometrical operations in the field could only be carried out during three or four months of the year, viz., from April to July. During the early part of the year heavy rains rendered the country impassable for wagon transport, and in July the natives begin to burn the grass, and the smoke from these grass-fires makes distant objects invisible. Pleuropneumonia broke out among the transport oxen in 1899, and at the same time the members of the beaconing party that was working ahead were all disabled by fever. A little later horse-sickness broke out and all the horses died within two weeks. As a result of this state of affairs in 1899 and of the unexpected delays in 1901, including the loss of the services of Mr. Heatlie, Mr. Simms' chief assistant, who was struck down at the beginning of the season by a severe attack of typhoid fever, three stations south of the Zambesi could not be occupied by the theodolite before August, when the smoke from grass fires became so dense that no more horizontal angles could be measured.

For operations north of the Zambesi a new organisation had to be established under the administration of North Eastern Rhodesia, and considerable delay arose before financial and other arrangements could be made.

It seemed, therefore, desirable to reduce and publish the results of the Survey of Southern Rhodesia, and they will be found in detail, together with an account of the operations, in Vol. III. of the Geodetic Survey of S. Africa.[5]

The plan of the triangulation will be found in the General Map.

Preliminary steps for starting the Survey of the Transvaal and Orange River Colony, 1901.

Meanwhile, in 1901, I had been engaged in much correspondence with Lord Milner and the officials of his staff, and also with the Intelligence Division of the War Office, on the subject of the Survey of the Transvaal and Orange River Colony. Lord Milner was convinced of the fact that amongst the first essentials to good Government are good maps of the country, but he felt that, until 1902, it would be premature to attempt a commencement of the work of Survey.

Votes, however, were placed on the estimates for 1901–2, viz., £10,000 by the Transvaal and £5,000 by the Orange River Colony, but no actual steps were taken to advance Survey operations.

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[5] *See* footnote p. viii.

Early in 1902 a considerable amount of preliminary correspondence took place with reference to starting Survey operations, and finally the following letter was written by Lord Milner's request :—

ROYAL OBSERVATORY,
CAPE OF GOOD HOPE,
6th May, 1902.

Re Survey of the Transvaal and Orange River Colony.

MY LORD,

Referring to a recent conversation on this subject, and to some previous informal correspondence, I would now, in accordance with your wishes, point out some of the preliminary steps which, it seems to me, should be taken in the way of preparation for the work.

I understand it is your desire to make arrangements not only for the execution of the primary triangulation of the Transvaal and Orange River Colony, but to follow that work up, as quickly as possible, with the secondary triangulation and topography, and to complete in the first place those maps which are most urgently required for administrative purposes.

The principal triangulation must of necessity be carried out at once as a whole, so that mapping based on it may be begun in any part of the country.

The processes involved are:—

1. Execution and adjustment of Primary Triangulation.
2. " " Secondary Triangulation (sides of 3 to 8 miles).
3. Topography and map making.

I do not insist that these steps should each be successively completed one after the other,—although that is the ideal condition.

The principal triangulation of a particular part of the country can be completed, and the secondary work and mapping can then follow—provided that our new principal triangles are first connected with the existing system of principal triangulation in other parts of South Africa.

I am now preparing a map[6] showing all the principal triangulation now executed in South Africa, and a proposed plan for the principal triangulation of the Transvaal and Orange River Colony. This I will forward so soon as it is ready.

Meanwhile, enough has been said to show that our first start must be principal triangulation connected with the triangles of the Geodetic Survey in the north of Natal, and with the triangles on the western boundary of the Orange River Colony.

The instruments for principal triangulation are not things kept in stock—they have to be made to order, and scientific instrument makers work slowly. I would urge the desirability of having the principal instruments put in hand at once, and suggest that I may have permission to order such instruments—their total cost not to exceed £1,000.

I have the honour to be,
Your Lordship's obedient Servant,
(Signed) DAVID GILL,
H.M. Astronomer.

Sir D. Gill visits Transvaal.

At the invitation of Lord Milner, I visited Johannesburg early in July, 1902, to discuss survey questions, and arrange preliminaries for starting the work. It was agreed that application should be made to the War Office for the services of Colonel Morris, as head of the New Survey Department, and the following letter was addressed to the Colonial Secretary :—

Services of Colonel Morris applied for.

JOHANNESBURG,
9th July, 1902.

SIR,

I have discussed with Lord Milner the suggestions made in my private letter to you of yesterday's date with reference to the methods which should be adopted for the intercolonial adjustment of costs of Ordnance Survey of the Transvaal and Orange River Colonies which is about to be undertaken.

These suggestions are the following :—

1. The general principle should be accepted that the cost of Survey be ultimately divided between the two Colonies in proportion to the area surveyed or mapped in each.
2. That the whole of the salaries and other costs of the two surveys should be paid for in the first instance by the Government of the Transvaal.
3. That contributions to the cost of the General Survey be paid to the Government of the Transvaal from time to time in round sums by the Orange River Colony.

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[6] The map in question was forwarded on the 31st May.

4. The Superintendent of the Survey shall from time to time indicate the amounts of payments to be made under para. 3, so that, roughly speaking, when a final adjustment of accounts comes to be made, there may remain no very large sum to be paid on either side for the final adjustment of accounts.

Lord Milner approves of this proposal, and suggests that if it is also approved by you it should be submitted for approval of the Government of the Orange River Colony, and, if approved, be adopted

I have the honour to be, etc.,
(Signed) DAVID GILL.
H.M. Astronomer.

The Colonial Secretary, Pretoria.

On the 10th July, 1902, the Executive Council passed the following Minute :—

Considered the following proposals by the Colonial Secretary on the subject of the Ordnance Survey of the Transvaal and Orange River Colony.

1. That the post of Superintendent Ordnance Survey, Transvaal and Orange River Colony, be offered to Colonel Morris, R.E., on a salary of £1,500 per annum, plus a local personal allowance—while Colonel Morris holds the office—of £250 per annum, with Captain C. G. Close, R.E. as his assistant on £1,000 per annum, the appointments to commence from dates of assumption of duty.
2. That the Government of the Transvaal shall make such payments from time to time as may be necessary, and that the proportion due by the Orange River Colony shall be adjusted twice yearly on the report of the Superintendent, Ordnance Survey, who shall assign the cost in proportion to the value of the work actually done in each Colony.

That the programme for the Grand Triangulation proposed by Sir David Gill, Astronomer Royal, be approved as a basis for the guidance of the Superintendent, Ordnance Survey.

That any excess required for the working of the two main surveying parties for the current financial year, beyond the £5,000 provided in the Estimates, be met in Supplementary Supply.

Proposals agreed to, subject to approval being received from the Lieutenant-Governor of the Orange River Colony.

C.S. 6658/02 Ordnance Survey of Transvaal and Orange River Colony.

On my return to Cape Town, the following letter was addressed to the Colonial Secretary, Pretoria :—

ROYAL OBSERVATORY,
CAPE OF GOOD HOPE,
5th August, 1902.

SIR,

Preliminary Estimates of Cost of Survey.

In accordance with the results of conversations with Lord Milner at Johannesburg, and with yourself at Pretoria, I have discussed with Colonel Morris a number of matters in connection with the Survey, and have prepared some preliminary estimates and proposals, your sanction of which would greatly facilitate the commencement of regular operations.

(1.) The enclosed annexure No. 1 gives an approximate estimate of the cost of starting work in the field on the scale which is contemplated by the instructions which I drafted in connection with Colonel Morris's appointment. We estimate these as rather outside figures, having regard to our uncertainty as to the cost of work in the Transvaal generally.

The cost naturally divided itself into two classes, viz.,—Outfit and Annual charge.

To start two complete parties in the field will require a capital outlay for outfit of £4,000, distributed as follows :—

		£	£
A.	2 transportable Observing Huts, at £80	160	
	4 specially made Cape Carts, at £75	300	
	14 Scotch Carts with springs at £25	350	
			810
B.	Tents and Cooking Equipment	288	
	Harness and General Equipment	310	
			598
C.	24 Horses, at £30	720	
	56 Mules at £30	1,680	
			2,400
D.	Contingencies		192
			£4,000

The above equipment is explained in detail in Annexure No. 1.

Items under head A require to be specially made, and I recommend that Colonel Morris be empowered to order these articles where former experience showed that they could be supplied of the most durable and suitable kind.

If this could be granted *now* much time would be saved. Articles under head B require less time to make, and we could afford to wait a few weeks before ordering them.

Horses and mules (under head C) can probably be purchased from the military department when required.

Contingencies (head D) are only introduced to balance the Estimate.

(2.) The Estimate of Annual Expenditure, viz., £18,750, provides for two complete field parties, and the pay of Superintendent and Assistant Superintendent.

It may naturally be asked, why provide for the two latter officers, who apparently are without duties beyond those of supervision? The answer is that when these officers have organised the commencement of the work of the two trigonometrical parties, they will be free to organise the work of base measurement, and will themselves undertake that work, employing men temporarily employed and trained for the purpose. It would be economical for them to complete the base measurement of all the base lines for the whole system whilst they are about it.

By the time that is done the third trigonometrical party could be started, Captain Close meanwhile devoting himself to the organisation of a School of Topography, and the training of men for the topographic work. Colonel Morris would by this time have sufficient data coming in to start his Computing Office, and be devoting himself to the general organisation of his department, including preparation of the plant for production of maps, &c.

The annual cost of the base line measurement will be considerably less than that of the third trigonometrical party, so that according to these plans the total expenditure would not exceed £25,000—which is the rate of expenditure agreed upon—including provision of £1,000 for instruments.

(3.) In the next year there would be a saving of Capital outlay of £6,000 as compared with the first year, which would be available for the commencement of secondary triangulation and the training of topographers.

(4.) As the work advanced the amount of primary triangulation might be reduced, and one, and finally all, the primary survey parties could be transferred to secondary triangulation.

The Secondary Survey parties do not require heliogragh parties attached to them, and I think also it will be possible to train less highly paid men for this work, so that each year, as the work proceeds, the expenditure will be thrown more and more on topography and map production, and the senior field officers will become superintendents of groups of plane-tablers, each group being engaged on the topography of a considerable area.

(5.) How far it will be desirable or possible to employ the natives of India for the work of plane-tabling (topography) must remain for future experiment.

As a preliminary trial I have written to the Surveyor-General of India for the loan of two officers and signallers for service between the Zambesi and Tanganyika. If the experiment succeeds there, it may be worth while to consider whether natives of India might be employed in the Transvaal and Orange River Colonies. If successful, the plan would be a very economical one.

(6.) It seems unnecessary to further foreshadow the details of the work. Sufficient has been said to indicate the basis of the estimates which are submitted, and the general trend of the work.

(7.) In regard to the control of standards of length, &c., it seems desirable to utilize the apparatus belonging to the Royal Observatory at the Cape. The work of comparison of thermometers, Jäderin apparatus, steel tapes, &c., can be performed there at far less cost than would be involved in creating a Standard Office at Pretoria or Johannesburg.

For the proper standardization of Jäderin wires it will be necessary to erect a shed 100 feet in length, which can be done on the Observatory Grounds. I will obtain an estimate of the cost at an early date.

I have the honour to be,
Sir,
Your obedient servant,
(Signed) DAVID GILL,
H.M. Astronomer.

Annexure No. 1.

ESTIMATES IN CONNECTION WITH COST OF ORDNANCE SURVEY OF THE TRANSVAAL AND ORANGE RIVER COLONIES.

	£.	Outfit. £.	Annual. £.
Superintendent, Colonel Morris			1,750
Assistant Superintendent			1,000
No. 1 Trigonometrical Party.			
Captain ...., R.E.	800		
Booker and Accountant, &c.	200		
Conductor	175		
8 Natives and food say	400		
Food and shoeing for 10 horses (2 carts)	360		
„ „ „ „ 4 mules (1 Scotch cart)	144		
Contingencies	221		
			2,300
2 Cape carts, with hoods, &c. at £75	150		
1 Scotch cart on springs	25		
Tents and cooking utensils	60		
Observing hut (transportable)	80		
10 Horses, for 2 Cape carts and 2 span at £30	300		
4 Mules for spring cart at £30	120		
Equipment—harness, &c.	60		
Sundries	5		
		800	
No. 2 Trigonometrical Party.			
As in No. 1		800	2,300
No. 1 Reconnaissance Party.			
Lieutenant Dunman, R.E.	400		
2 Natives and food	100		
Food and shoeing for 4 mules	144		
„ „ „ „ 2 horses	72		
Contingencies	34		
			750
Scotch cart on springs	25		
Purchase of 4 mules	120		
„ „ 2 horses	60		
Tents and cooking equipment	14		
Equipment for horses, saddles, &c.	20		
Contingencies	11		
		250	
No. 2 Reconnaissance Party. (Captain Campbell, R.A., or a Lieutenant, R.E.)			
Cost as of No. 1		250	750
No. 1 Beaconing Party.			
1 Beaconer	300		
2 Natives and food	100		
Food and shoeing (4 mules)	144		
Contingencies	26		
			570
1 Scotch cart on springs	25		
4 Mules	120		
Tents	14		
Equipment	15		
Contingencies	16		
		190	
Carried forward		2,290	9,420

	£	Outfit. £.	Annual. £.
Brought forward		2,290	9,420
No. 2 Beaconing Party.			
As above		190	570
4 Heliograph Parties for Trigonometrical Party No. 1.			
4 Heliographers .. .. at £200	800		
8 Natives .. .. at £50	400		
Food and shoeing for 16 mules	576		
Contingencies	104		
			1,880
4 Scotch carts on springs	100		
16 Mules .. .. at £30	480		
4 sets of tents and cooking utensils	56		
Equipment—harness, &c.	60		
Contingencies	64		
		760	
4 Heliograph Parties for Trigonometrical Party No. 2.			
As above		760	1,880
		£4,000	£13,750

Additional Cost of 3rd Survey Party.

	Equipment. £.	Annual. £.		
No. 3 Trigonometrical Party	800	2,300		
Reconnaissance Party	250	750		
Beaconing Party	190	570		
4 Heliograph Parties	760	1,880		
			2,000	5,700
			6,000	

Annual	19,450
Outfit	6,000
Total	£25,450

The Honourable,
The Colonial Secretary,
Pretoria.

DAVID GILL.

After a good deal of further correspondence a letter was received to the effect that Colonel Hoskyns, R.E. had sailed on the 24th September to relieve Colonel Morris from his duties as C.R.E. at Cape Town, so that the latter's services would be available for the Geodetic Survey of the Transvaal about the 25th October.

Many duties at the Cape prevented me from taking direction of the Survey, and my connection with it was defined, at my own request, as follows :—

High Commissioner's Office,
Johannesburg,
14*th October*, 1902.

Sir David Gill appointed Scientific Adviser to the Governments of the Transvaal and Orange River Colony.

Sir,

The Governments of the Transvaal and the Orange River Colonies have, as you are aware, resolved to undertake an Ordnance Survey, and in accordance with your advice, have appointed Colonel Morris, R.E., C.B., C.M.G., Superintendent of the Survey in question.

Having regard to the active interest which you have taken in the promotion of accurate Survey Operations in South Africa, and knowing your desire to promote the extension of the Great Geodetic Arc along the 30th Meridian which you have projected and already so far carried out, I am desirous of having your advice on all matters connected with such operations in South Africa. It seems to me that in this way only can that unity of purpose and design be maintained which is essential for the efficient and economical arrangement of the work in the different Colonies, and their combination as a harmonious whole.

As all accurate Survey Operations in South Africa subsequent to 1879 have been carried out either under your direction or in accordance with plans laid down by you, I trust that I may reckon upon your assistance as Scientific Adviser to the Governments of the two Colonies in all matters connected with Survey Operations, and I enclose a copy of Colonel Morris' letter of appointment in writing, in which I ventured, basing myself on your verbal assurances, to assume, that you would be prepared to accept that honorary position.

In the meanwhile I should be glad if you would take steps to secure the instruments necessary for the work—the cost of which, I understand, will not exceed £1,000.

I have the honour to be, Sir,
Your obedient servant,
(Signed) MILNER, Governor.

The duties of Colonel Morris were defined as follows:—

High Commissioner's Office,
Johannesburg,
14th October, 1902.

Sir,

Colonel Morris appointed Superintendent of the Survey of the Transvaal and Orange River Colony.

I have the honour to inform you that the Governments of the Transvaal and the Orange River Colonies have decided to set on foot as soon as possible a systematic survey, having for its object the construction of complete maps of both Colonies on a scale or scales to be subsequently determined.

The emoluments of the post of Superintendent of this Ordnance Survey are fixed at £1,500 per annum, but having regard to your previous experience in the Geodetic Survey of the Cape Colony and Natal, your seniority in rank, and the fact that your acceptance of the post may have the effect of diminishing your ultimate retiring pension from the Imperial Service, the salary would, in the event of your acceptance of the post, be accompanied by an annual additional allowance of £250.

The principal triangulation is to be carried out on the general plan shown on the map prepared by Sir David Gill, with which, it is understood, that you concur. Of this principal triangulation the following portions are to be first undertaken:—

1. A chain of triangles running along the 30th Meridian, from the northern end of the Geodetic Triangulation of Natal to the Limpopo.
2. A chain of triangles running through the Orange River Colony from the existing Geodetic triangles a little north of Kimberley, eastwards to the northern triangles of the Geodetic Survey of Natal.

When the triangles of the first of the above-mentioned chains reach the latitude of Johannesburg, a base line will be measured on suitable ground between Newcastle and that point, and provision will be made for a third Geodetic party in order to push on the longitude chain which runs eastwards from Mafeking, and also to complete the junction between Mafeking and the triangles connecting with Kimberley.

Meanwhile preparation will have to be made for setting on foot secondary triangulation of the country in the neighbourhood of Johannesburg and Pretoria, as well as Bloemfontein, as the Governments are most anxious to have maps of the country at the earliest date that is consistent with the definitive execution of the work.

In the event of your acceptance of the post, you will confer with Sir David Gill on the details of preparation—instrumental and otherwise—as the Governments (having regard to the interest which Sir David Gill has taken in promoting Survey Operations in South Africa) regard him as their Scientific Adviser in such matters, and are desirous of working in harmony with his general plans, especially in connection with his proposed Great Arc of Meridian.

Whilst you will report and be directly responsible to me as the Governor of the two Colonies, and will correspond with me on all matters connected with the Survey, you will maintain correspondence with Sir David Gill, and furnish him with any data he may desire in connection with the work, in order to enable him to preserve the continuity of his reports on the progress of Survey in South Africa.

I am, Sir,
Yours faithfully,
(Signed) MILNER.

Colonel Morris, R.E.,
The Castle,
Cape Town.

Proposals from the War Office for a general topographic survey of British S. Africa, 1903.

It will be seen that, thus far, it was Lord Milner's desire to carry out both a Trigonometric and Topographic Survey of the Transvaal and Orange River Colony. In 1903 I received a letter from the Colonial Secretary in Pretoria, dated March 18, informing me that the War Office was desirous of having topographic maps of all South African Colonies, and that it was prepared to contribute, up to certain limits, the pay of all the officers and men required to do the work, and inviting me to come to Pretoria as soon as possible to concert measures. It was impossible to comply with this invitation at once, for I was then organising the expedition, under Dr. Rubin, which was to sail from Cape Town on the 25th April for Chinde, and thence up the Zambesi to Zumbo, for measurement of the arc of Meridian from that point to Tanganyika, but I promised to start for Pretoria on the 3rd of May.

On arrival at Pretoria I ascertained, from correspondence there placed at my disposal, that this proposal for co-operation on part of the Imperial Government had arisen out of a suggestion made by Colonel Morris in course of an informal correspondence with Colonel Trotter, R.A., who was at that time in the Intelligence Department of the War Office.

In a letter, dated December, 1902, Colonel Morris wrote to Colonel Trotter as follows:—

> I think this (the topographical survey of S. Africa on a uniform plan) can only be done by some kind of co-operation between the War Office and the Colonial Governments concerned. What form this co-operation is to take is a difficult matter to decide; but one way of arranging would be for the War Office to give the services of officers, non-commissioned officers and men . . . .—the Colonial Governments paying the difference between regimental pay of the several ranks and the salaries proposed . . . . . . In the meanwhile, if the Colonies will accept this principle of co-operation, they should be called upon, themselves, to formulate their ideas as to the kind of map they require. The War Office Committee and the Committees of the several Colonies should come together at some definite time and place to discuss the whole problem of ways and means and of delineating the topography of the country and the particular forms and details of the maps that are to be produced.

Sir David Gill visits Pretoria and Johannesburg *re* War Office proposals 1903.

After a good deal of discussion with the various heads of departments at Pretoria, the following minute, dated 9th of May, 1903, was prepared and handed to the Colonial Secretary for submission to the High Commissioner on his arrival that day in Pretoria from Johannesburg:—

"*Pretoria, Transvaal,*
9th May, 1903.

Sir David Gill proposes that principal triangulation of Transvaal and Orange River Colony be completed before the topographic survey is begun.

"MINUTE with reference to a despatch from the Secretary of State to the High Commissioner, dated 21st March, 1903, on the subject of a General Topographic Survey of South Africa."

The proposals contained in the above-mentioned despatch should largely affect the policy to be followed in connection with the Survey of the Transvaal and Orange River Colony.

The proposal is that, as the War Office is interested in securing reliable topographic maps of the whole of British South Africa south of the Zambesi, the Imperial Government would be willing, on certain conditions, to grant the regimental pay of officers, non-commissioned officers, and men for that work to the extent of about £5,000 a year, provided that the various South African Colonies would agree to provide the additional local pay and other expenses connected with the work, estimated to amount to some £25,000 a year.

With this expenditure it is estimated that the work would be completed in 15 to 20 years.

It is obvious that the details of the terms of agreement between the Imperial Government and the South African Colonies will require consideration; but the general principle should be accepted for the following reasons:—

(1.) The economy in organisation and execution of the work resulting from its control being centralised.

(2.) The perfect uniformity of system throughout South Africa which could be thus secured.

(3.) The assurance of considerable aid from the Imperial Government.

(4.) The demonstration of the advantages of Inter-Colonial co-operation and the promotion of Federation.

Granting then that such a policy is likely to be adopted, how does this affect our present survey policy?

There exists at present in the Cape Colony and Natal a complete system of principal geodetic triangulation. A good deal of geodetic work has been done in Southern Rhodesia. It seems then desirable, in the first place, to put the Transvaal and Orange River Colony on the same footing as the Cape Colony and Natal in the matter of principal triangulation; that is to say, to devote all available survey funds to the completion of the principal triangulation as quickly as possible.

With the knowledge we now have of the cost of work here this can be very closely computed. I have gone very carefully into the matter with Colonel Morris, and find that, with an annual expenditure of £25,000, the principal triangulation of both these Colonies could be completed in three years.

We estimate also that the area covered by the principal triangles will be in the proportion of 7 to 18; so that if the Orange River Colony would contribute £7,000 a year instead of £5,000 as at present, and the Transvaal £18,000, the final settlement would not leave much to be paid by one Colony to the other when the actual areas covered by the triangles are measured.

We are also agreed that the work can be most economically done on a total expenditure of £25,000 per annum, as this will enable us to throw a complete survey party into the Orange River Colony in addition to the parties working in the Transvaal, and that, in order to prevent delay, the Transvaal should put £20,000 on the estimates for the Financial Year 1903–4 in case of refusal on part of the Orange River Colony.

Also that the sum of £2,500 should be advanced to Colonel Morris *at once* to procure equipment for the additional field work, and have all ready to start on the new basis in the beginning of July—the new Financial Year.

(Signed) DAVID GILL.

The following minute was passed by the Executive Council on the same date (9th May):—

Executive Council approves Sir D. Gill's proposal.

The Colonial Secretary, with the concurrence of the Commissioner of Lands, introduced for the consideration of the Council certain proposals of Sir David Gill, providing for the early completion of the principal Triangulation Survey of the Transvaal and Orange River Colony now being undertaken under the supervision of Colonel Morris, C.B., C.M.G., R.E., and for the commencement thereafter, with the co-operation of the Governments of all the British Possessions in South Africa and of the Imperial Government, of a General Topographic Survey of all British territory south of the Zambesi under centralised control.

The proposals involve:—

1. The consent of the Transvaal Government to contribute from £54,000 to £60,000, according to the amount of the contribution of the Government of the Orange River Colony, during the next three years of the federal budget towards the cost of the Principal Triangulation Survey.

2. The consent of the Transvaal Government to an expenditure from its revenues of a proportion of the amount required for the completion of the General Topographic Survey, on the basis of contribution to be arranged between the Imperial Government and the Governments of the British Possessions in South Africa.

It has been ascertained that as the War Office is interested in securing reliable topographical maps of the whole of British South Africa south of the Zambesi, the Imperial Government would be willing, on certain conditions, to lend for the work the necessary Officers, Non-commissioned Officers and Men of the Corps of Royal Engineers and to grant the regimental pay of these officers and men.

Sir David Gill has kindly consented to place his services at the disposal of the Transvaal Government in the negotiations which will have to be undertaken with the Government of the Orange River Colony to secure its concurrence in the expenditure necessary to complete the Principal Triangulation Survey of the Transvaal and Orange River Colony, and in the negotiations which will have to be undertaken with the Imperial Government and the Governments of the British Possessions in South Africa to secure their co-operation in the scheme of the General Topographic Survey of the whole of British South Africa.

RESOLVED:—

1. That the proposals are approved.

2. That the Transvaal contribute during the financial year 1903–4, the sum of £20,000 or such less sum as will, with the contribution to be provided by the Government of the Orange River Colony, make up a total sum of £25,000 to the federal budget for the Principal Triangulation Survey of the Transvaal and Orange River Colony, and a similar sum for the same purpose in succeeding years until the work of the Principal Triangulation is completed.
3. That to enable Colonel Morris to procure at once the additional equipment required for the extended scheme of field work which will, on the new basis, be started in the beginning of July, a sum of £2,500 be transferred from the Vote allowed to the Surveyor-General in the estimates of the current financial year for Minor Triangulation, £5,000, to the credit of Colonel Morris.
4. That the Governments of the various British possessions of South Africa be approached with a view to the securing of their co-operation in the General Topographical Survey to be commenced as soon as the Principal Triangulation Survey of the Transvaal and Orange River Colony has been completed.
5. That the Imperial Government be asked to state definitely what contribution it is prepared to make towards the expenses of the General Topographical Survey.
6. That the Government of the Transvaal gratefully accepts the offer of Sir David Gill to represent its interests in the negotiations with the Government of the Orange River Colony, in connection with the contribution that that Government will be asked to make towards the completion of the Principal Triangulation Survey of the Transvaal and the Orange River Colony, and in subsequent negotiations with the Imperial Government and the Governments of the various British possessions in South Africa in connection with the General Topographical Survey.
7. That the thanks of the Government of the Transvaal be conveyed to Sir David Gill for the readiness with which he has placed his high scientific attainments and experience at the disposal of the Government, to the great advancement of its schemes for securing the correct and adequate cartography of the Transvaal.

The matter was put into practical form by the following despatch addressed by His Excellency the High Commissioner to the Governors of the various South African Governments:—

His Excellency the High Commissioner to His Excellency the Governor.

High Commissioner's Office,
Johannesburg, 18*th May*, 1903.

Sir David Gill's mission to different South African Governments.

SIR,

I have the honour to inform you that I have received a Despatch from the Secretary of State, relative to the undertaking of a systematic and uniform survey of the whole of British South Africa south of the Zambesi.

The Secretary of State is of opinion, and I agree, that the making of such a Survey is of first-class importance, and that it would greatly facilitate the Civil Administration and development of the country.

This proposal is accompanied by an offer on the part of the War Office to supply the services and regimental pay of a military staff of officers and surveyors from the Ordnance Survey Department of England, and the suggestion that a Central Office should be established for the execution of the work; the various South African Civil Governments supplying the difference between the regimental and Colonial pay and the other costs of the Survey.

The details of the proposal may be gathered from the original despatch, a copy of which is attached. These proposals have been communicated to Sir David Gill, K.C.B., who is now on a visit to the Transvaal, and he has expressed the opinion that, in view of the saving that must arise from centralisation of the work, and the advantage of securing uniformity throughout South Africa, the general principle suggested by the Secretary of State should be adopted. The assurance of considerable aid from the Imperial Government should also, he thinks, influence the various Colonies in favour of the scheme.

As regards the execution of the work, Sir David Gill points out that in the Cape Colony and Natal a complete system of geodetic triangulation already exists, and that a good deal of geodetic work has been done in Southern Rhodesia. He considers that the first thing to do is to place the Transvaal and the Orange River Colony on the same footing as Cape Colony and Natal in the matter of principal triangulation, that is to say, devote all available funds in these Colonies to the completion of the principal triangulation as quickly as possible. I have accordingly arranged to place the sum of £25,000 on the joint estimates of these Colonies for the financial year 1903–4, and Sir David Gill and Colonel Morris estimate that a like annual expenditure for three years will suffice to complete the principal triangulation of the Transvaal, Orange River Colony, and Basutoland. The final adjustment of accounts between these territories will be ultimately made by dividing the total cost in proportion to the area covered by the principal triangles in each.

The principal triangulation of the Transvaal could also, at very small expense, be extended to the territory recently acquired by Natal by the survey parties under Colonel Morris, and the proportional cost charged to that Colony.

For the more complete connection of the principal triangulation in the Orange River Colony and Basutoland with the system of triangulation in the Cape Colony, it is, in Sir David Gill's opinion, desirable to make short extensions of the arcs on the 26th and 28th Meridians; this could also be easily and economically accomplished by the survey parties under Colonel Morris, and the proportional cost charged to the Cape Colony.

With regard to Southern Rhodesia, Sir David Gill is of opinion that the principal triangulation will be sufficiently provided for when a connection has been made along the 30th Meridian between the northern triangles in the Transvaal and the existing triangles in Rhodesia. This could be most economically accomplished when the Transvaal survey party is engaged on work near the Limpopo. The cost of the work might be charged to the Rhodesian Administration in proportion to the area covered by the triangles on conclusion of the principal triangulation in the Transvaal and Orange River Colony.

Having regard to the desert character of a great part of the Bechuanaland Protectorate, and the fact that its most valuable parts are adjacent to the chain of principal triangulation along the Western Border of the Transvaal, the principal triangulation of the Protectorate seems, at all events for the present, to be sufficiently provided for. Thus it appears that, with the existing organisation, and with the consent of the Governments of the Cape Colony, Natal, and Rhodesia, to the extension of the Transvaal and Orange River Colony triangulation above suggested, provision is already made for completing all the necessary principal triangulation south of the Zambesi within three or four years.

It remains now for consideration in what manner and on what basis steps should be taken to give effect to the proposal of the War Office.

This proposal has been considered very carefully from the point of view of Civil Administration by Sir David Gill in conjunction with the Heads of the Administrative Departments of the Transvaal, and a report has been prepared by Lieut.-Colonel Jackson, R.E., Surveyor-General of the Transvaal, in which the opinion is expressed (in which the Heads of Departments unanimously concur) that a scale of half-an-inch to the mile is too small for administrative purposes, except where land is of small value, and that in cases where there is desert or wide featureless tracts of small value, a scale of ¼ inch to the mile would suffice. For the Transvaal it is estimated that, roughly speaking, one-half of the country should be surveyed on the scale of one inch to the mile, or, preferable, 1 in 50,000 (1 inch corresponds to 1 in 63,000), seven-eighths of the remainder on the ½-inch scale, or, preferably, 1 in 10,000,000, and the remaining one-sixteenth on the scale of 1 in 200,000.

The relative costs of these various scales of survey are estimated to be as nearly as possible proportional to the scale: thus the scale of 1 in 50,000 would cost double that of 1 in 100,000 and four times that of 1 in 20,000. It is, of course, impossible for me to recommend what scales and methods of mapping should be adopted by governments outside the Transvaal and Orange River Colonies. The whole matter is full of technical questions, and can only be settled by discussion between the various Governments and some person technically capable of doing so.

As I am desirous of preparing a plan for taking advantage of the Imperial proposal, I have requested Sir David Gill to discuss these details with your Government and to ascertain in the first place whether they are in favour of the general principle involved. My view in the matter generally is as follows:—

1. That a general statement of the requirements of the various Colonies should be prepared by Sir David Gill, after he has ascertained the views of the various Governments, for submission to His Majesty's Government, and that an endeavour should be made to arrange a scheme in accordance with the views of all concerned.
2. When such an arrangement has been arrived at, steps should at once be taken for the formation of a Central Office and Organization to undertake the secondary triangulation, minor triangulation, and topography of British South Africa south of the Zambesi.
3. That, as a principal triangulation of the Cape Colony and Natal is now completed, the minor triangulation and topography should be begun in these Colonies without delay. For this purpose I suggest that the equipment should be on the scale contemplated in the proposal under consideration, viz., an annual expenditure of £25,000 in addition to the military pay of Officers and Surveyors of the Ordnance Department, and that this expenditure should, until the principal triangulation of the rest of British South Africa has been advanced to the required stage, be defrayed by the Cape and Natal Governments jointly.
4. After three years or so, as soon as the principal triangulation of the Transvaal and the Orange River Colony has been completed, I propose that these Colonies shall add to the common fund an annual sum of like amount, so that the strength of the survey party may be doubled, and the work also carried on there.
5. After a year's work in the Transvaal and Orange River Colony, when the cost of the different scales of survey per 100 square miles has been approximately ascertained, the work shall be begun in Rhodesia and the Bechuanaland Protectorate, and annual subscriptions to the general fund arranged in proportion to the area and scale of map to be produced in each Colony or Protectorate.

The whole plan should be so arranged that, as nearly as possible, the annual subscription will in the end lead to the payment of comparatively small sums in the final settlement. This final settlement should be based entirely on the area surveyed in each, combined with the scale of the map. Thus areas surveyed on the scale of one inch to the mile (or 1 in 50,000) should count two areas, those on the ½-inch scale (or 1 in 100,000) should count one area, and those on the ¼-inch scale (or 1 in 200,000) should count half an area. These values are the nearest possible approximation to the actual cost; they may be so accepted, or be liable to modification after discussion or trial. This appears to me the basis of a fair working arrangement; but, as already stated, the details require very thorough discussion and adjustment to suit the views of all concerned.

I am convinced that a general agreement can only be arrived at by personal discussion, and for this purpose I trust you will give Sir David Gill, who fully understands my views, and has expressed his readiness to lend the aid of his valuable experience to the furtherance of the scheme, an opportunity of consulting with your Government, and of explaining in detail the proposals of which it is not possible, in a despatch, to give more than the general outline.

I have, etc.,
(Signed) MILNER,
High Commissioner.

Sir D. Gill proposes conference of Surveyors-General.

I accordingly visited Bloemfontein, Cape Town and Durban, returning again to Johannesburg to confer with Lord Milner and report the result of my mission. There were naturally a good many differences of opinion amongst the officials of the various governments, and I advised that an officer should be sent out by the War Office, as its official representative, to meet a Congress of Surveyors-General of the various South African Governments.

This proposal was adopted by Lord Milner, in the following letter addressed to Sir David Gill:—

High Commissioner's Office,
Johannesburg,
28*th July*, 1903.

Conference of Surveyors-General approved.

Sir,

I have the honour to acknowledge the receipt of your letter of July 10th, setting forth the present position of affairs in regard to the proposed general topographical survey of South Africa.

The High Commissioner has forwarded a copy of your letter to the Secretary of State with a request that the War Office may be approached in regard to your proposal that a Conference shall be held between the Surveyors-General of the various Colonies and a War Office representative.

His Excellency desires me to express his gratification at the manner in which you have carried out the preliminary negotiations, the result of which appears on the whole to be very satisfactory.

The Administrator of Southern Rhodesia will be asked to send a representative to the Conference when it meets, and, it is to be hoped, that that Government will eventually see fit to take part in the general scheme.

An extract from your letter from the words, "so far, therefore, as my mission is concerned," down to the words "so far as the Protectorates are concerned," is being forwarded to the Governors of Cape Colony and Natal the Lieutenant-Governors of the Transvaal and the Orange River Colony and the Administrator of Southern Rhodesia.

I have, etc.,
(Signed) C. H. RODWELL,
Acting Imperial Secretary.

The following letter addressed to Colonel Morris explains some of the departures from original plans:—

Royal Observatory,
Cape of Good Hope,
26*th Sept.*, 1903.

Modifications of the original plans.

Sir D. Gill to Colonel Morris.

Your long letter of the 22nd September I will deal with in separate letters—as you may require to use the replies for different purposes.

I concur rather reluctantly in postponement of the measure of the Limpopo Base; but I recognise that it is necessary in that region to take advantage of the most favourable season for the work, in the hope also that the horse-sickness which prevails just now may later on diminish, or some remedy be found for it. But you must make a vigorous attempt next winter to complete it. I think, from what I hear of the country, that most probably a little S.W. of Wepener you will be able to find a very suitable site for a base, probably near the Caledon River.

I enclose a copy of a letter which I have written to the Imperial Secretary[7] on the subject of carrying the geodetic chains through Basutoland. I will send you copies of any correspondence with me which may result.

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[7] See correspondence *re* Topographical Survey of British South Africa. Proceedings of Congress held at Cape Town, March, 1904. Presented to both Houses of Parliament by command of His Excellency the Governor. Cape Town, 1904.

I received the map showing the proposed triangulation in the Transvaal and O.R.C.

From the enclosed copy of Lord Milner's letter of the 18th May you will observe that it is proposed to make the following extensions.

A. To extend the arc along the 25th Meridian Southwards through Basutoland, and join the Cape Geodetic triangles in the Cape Colony near Cala.
B. To extend the longitude arc from Wepener Eastwards through Basutoland to join the Natal Arc.
C. To extend the longitude arc through Kroonstadt from Newcastle to the Sea Coast.
D. To extend the arc along the 30th Meridian from the Limpopo to the existing triangulation in Rhodesia, a little East of Gwelo.

As regards A and B, the matter is in the position which is explained above.

As to C, Natal concurs, and the work can be undertaken when most convenient.

As to D, I have written to the Chartered Company asking their concurrence.

With regard to my proceedings I send you copies of most of the correspondence, which will show you exactly how matters stand.

I am very glad to hear that King has been so successful in his reconnaissance. I have not got Jeppe's map beside me, and so cannot identify the site of the base he proposes; can you send me Jeppe's map and mark on it the suggested site of the base as well as the names and places of his points, as in the map you sent me the names of points are not given.

If the only possible site is considerably south of the Limpopo, we must try to get in another base if a good site can be found in Rhodesia, about midway between Salisbury and your base on the Brak River.

I should like also to have Dunman's points marked and named so that I can follow the progress of reconnaissance. Future reports could give me the names, latitudes and longitudes of points, so that we could lay them down here.

I regret to hear of the loss of time caused by waiting for the due share of A.M. observations as compared with P.M. I concur in giving a trial in a few triangles to the system of getting the necessary rounds either A.M. or P.M., as the observer can get them, and then comparing the errors of the triangles so measured with those of other triangles of the same character previously measured by the same observer when strict regard has been paid to the equal division between A.M. and P.M. observations. When this has been done we can come to a sound conclusion on the matter.

I am sorry to hear about the W.O. delays in sending officers to you. I write to Colonel Trotter by this mail on the subject. (Copy of letter enclosed.)

I am glad to hear you have got a good site at Ottoshoop for the Base, with a water supply.

I have just received from Colonel Lallemand all the papers necessary for completely following the whole of the French levelling system. I send the papers and a separate letter on the subject.

(Signed) DAVID GILL.

The Congress of Surveyors-General met at Cape Town on the 1st, 2nd, 3rd, 4th, and 6th of March, 1904, under the Presidency of Sir David Gill. A *précis* of its proceedings was printed and laid on the table of both Houses of Parliament of the Cape Colony the same year.[7]

The resolutions arrived at were as follows :—

The Congress of Surveyors-General recommends :

Recommendations made by the Conference of Surveyors-General.

1. That a general Topographical Survey of the British Colonies and Protectorates in Africa south of the Zambesi is, in the opinion of this Congress, desirable.
2. That this Topographic Survey shall be undertaken by a single Department working under a single Responsible Director.
3. That the title of this Department, hereinafter designated the Central Office, shall be "The Topographic and Geodetic Survey of South Africa."
4. That the Headquarter Offices of this Survey shall be at Cape Town.
5. That the Government of the Cape Colony be approached with a view to obtaining a grant of Crown Land on which to erect the Headquarter Offices.
6. That the secondary Triangulation in the Cape Colony be carried out under the direction of the Surveyor-General of that Colony, employing duly admitted Colonial Surveyors on the work, and that the Topographic Survey be conducted by the Central Office on the understanding that:
   - (*a*) The Surveyor-General of the Cape Colony shall undertake to supply the Central Office with details as to the positions of the points of the Secondary Triangulation, the sides of which will average about eight miles in length.
   - (*b*) The Central Office shall mark all its stations in a permanent manner, and shall furnish the Surveyor-General of the Cape Colony with details of their positions, so that they may be utilised in the "Tertiary" Triangulation for Cadastral purposes.

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[7] Topographical Survey of South Africa—Proceedings of Congress held at Cape Town, March, 1904. Presented to both Houses of Parliament by Command of His Excellency the Governor.

7. That the Secondary Triangulation of the Colony of Natal, so far as it has not already been completed, shall be carried out by the Surveyor-General of that Colony in co-operation with the Director of the Topographical Survey.

8. That the Government of Rhodesia be requested to consider the advisability of undertaking the extension of the existing Arc of Meridian southwards to the Limpopo to join the Triangulation now being carried out under the direction of Colonel Morris in the Transvaal, thus completing a backbone of Primary Triangulation running right through the country, which would form a basis for all future operations.

9. That in order to give greater elasticity to the working of the Central Office, to allow of exchange of officials, to minimise office expenses, and to ensure effective co-operation, the Topographic and Geodetic work shall be carried out by the same Department under the same Director, except as regards the Triangulations of Cape Colony and Natal, which may be carried out in accordance with the provisions of Resolutions 6 and 7, provided that the military officer selected for the Directorship of this Department be the present Superintendent of the Trigonometrical Survey of the Transvaal and Orange River Colony.

10. That in order to insure that the Topographic Survey shall fulfil the following conditions, essential from the point of view of the Colonial Governments, viz. :—

(*a*) That it shall be as useful for the general purposes of the Civil Administration as the scale admits; and

(*b*) That it shall be sufficiently accurate for the connection of the Farm Surveys in one homogeneous system,

it is necessary :—

(1.) That the triangulation carried out by the Central Office should be sufficiently close and sufficiently accurate to fulfil both the above conditions, and that these conditions would probably be met by such a triangulation as would give fixed points at such distances that their positions on the maps, when projected on any previously adopted scale, would be on an average four and a half inches (4½ in.) apart; and, as regards accuracy, such that the average triangular error would not exceed in Secondary work 5″, and in Tertiary work 20″.

(2.) That all the stations of observations used in these triangulations be permanently and characteristically marked, *i.e.*, either by a certain uniform mark on rock *in situ*, or on a mark-stone securely embedded; and that a substantial cairn shall be built symmetrically over each mark.

(3.) That the complete data and triangulation charts of all points fixed in these triangulations, both of stations of observation and of intersected points of the triangulations, and of as many plane-table points as possible, be determined, and also such other auxiliary heights shall be determined that the average total number of resulting height determinations be not less than two per square inch on the maps.

11. That it be recommended that all officials of the Central Office be granted free railway passes when travelling on duty.

12. That the maps be produced on the following scales :—

As an equivalent of ¼ inch to the mile, 1/250,000.
" " " ½ " " 1/125,000.
" " " 1 " " 1/62,500.
" " " 2 " " 1/31,250.

and that these different scales be used according to the requirements of the different parts of the country, the areas of which have been approximately indicated by the Surveyors-General of the respective Colonies to be as follows :—

Cape Colony—

On the ½-inch scale, 170,000 square miles.
" 1 " " 100,000 "
" 2 " " 1,200 "

Natal—

On the 1-inch scale, 85,000 square miles.
" 2 " " 500 "

Orange River Colony—

On the 1-inch scale, 50,000 square miles.

Transvaal—

On the ½-inch scale, 64,000 square miles.
" 1 " " 48,000 "

13. That in the maps to be produced, the hill features shall be presented by a system of contours (form lines), which shall be controlled by trigonometrical, barometrical, and clinometric heights. The contour lines shall be shown in a warm brown tone, and the hills shaded in a grey tone, as in the French 1/50,000 Colonial maps. The deepness of the shade shall represent the steepness of the slope, independent of any imaginary direction of incident light.

Woods shall be shown in green.
Detail " " " " black.
Water " " " " blue.

Permanent sources of water supply shall be described.

Names of places shall be engraved, and height-numbers shall be expressed in Imperial feet above mean sea level, and shall be printed in brown.

The contour lines shall be at vertical intervals of one hundred feet (100 feet) for the scale of 1/125,000, and for other scales shall be at proportionate distances.

Other conventional signs shall be as in Military Maps.

There shall be special signs for certain South African features, and for good cart-roads, bad cart-roads, bridle-tracks, and footpaths.

For the scale of 1/250,000 the contour lines shall be omitted, the features generalised, and the shading reproduced by some photo-mechanical process.

14. That each sheet of the maps shall cover an area of 40′ in longitude by 30′ in latitude on the scale of 1/250,000, and that the area covered by each sheet on any other scale shall be in proportion; the linear dimensions of the sheet being maintained.

15. That a small lithographic establishment shall form part of the headquarter office, for the purpose of producing Trigonometrical Charts, survey forms and copies of field sheets, and eventually, if found to be economical, for the printing of the final maps. It is considered, however, that in view of the expense of engraving and lithographic work in South Africa, the maps should, for the first few years, be printed by the Ordnance Survey of Great Britain and Ireland, if the Director-General of the Ordnance Survey will undertake the work on payment and on the system approved by the Congress.

16. That more definite arrangements be made in regard to the supply of Maps required by the War Office. The Congress suggests that, so long as the Maps continue to be printed at Southampton, the War Office shall have the right to retain 250 copies free of charge. The Copyright of the Maps shall remain the property of the Governments of the respective Colonies.

17. That there shall be established in connection with the Central Office a School for training in Topography and other branches of Surveying to which, *inter alias*, men who have obtained the Certificate of Proficiency in the Theory of Surveying shall be admitted on payment of reasonable fees.

18. That the following method of apportioning the cost of Survey amongst the various Colonies be adopted:—

(1.) That the accounts of the Central Office be kept in such a manner as to determine the actual cost of field work annually executed in each Colony, and the said cost shall be debited as a first charge against the annual contribution of each Colony.

(2.) That the cost of reproduction, printing and publication of Maps be similarly dealt with and charged.

(3.) That the cost of administration for each year shall be charged against each Colony in proportion to the charges under heads (1) and (2) above-mentioned.

According to the above recommendation each Colony will be charged exactly the expenditure incurred in, and on behalf of, that Colony. In this way it does not matter whether a Colony does its own Primary, Secondary or Tertiary Triangulation, or whether it employs the Central Office to do it. The partition of cost will thus in every respect be an equitable one.

19. As a preliminary estimate of the annual cost of the work to be performed by the Central Office for the different Colonies the annual contributions of the Colonies to the Central Office shall be as follows:—

	£
Cape Colony	14,000
Transvaal and Orange River Colonies	25,000
Natal	5,000

(Signed) DAVID GILL, Chairman.
C. F. CLOSE, Major, R.E., representing the War Office.
MAX JURISCH, representing Cape Colony.
J. MASSON, representing Natal.
H. M. JACKSON, representing Transvaal.
BURNET ADAMS, representing Orange River Colony.
W. J. ATHERSTONE, representing Rhodesia.
VICTOR A. LOWINGER, } Secretaries.
ARNOLD PILLING, }

These very practical resolutions, which all the Governments were at first prepared to adopt, would, by the establishment of a central office and a systematic organisation, have placed the question of survey in South Africa on a sound working basis for all time.

Most unfortunately, however, towards the middle of 1904 a financial crisis occurred in South Africa generally, which at first pressed more severely on the revenue of Cape Colony, but soon afterwards extended to Natal, the Transvaal, and Orange River Colony.

The financial crisis and the withdrawal of the various Governments from the proposals of the Conference.

Ministers, in face of a greatly diminished revenue, did not feel justified in undertaking fresh expenditure. Accordingly, Cape Colony withdrew from the provisional agreement, and Natal followed suit. Finally, the Transvaal and Orange River Colony gave up any immediate intention of starting Topographic Survey, and resolved to dismiss the Survey party under Colonel Morris on completion of the Geodetic Survey.

The further history of Geodetic Survey in South Africa, so far as the Transvaal and Orange River Colony are concerned, will be found in the accompanying report of Sir William Morris.

The Geodetic Survey north of the Zambesi.

Meanwhile, as already stated, Dr. Rubin sailed from Cape Town on the 25th April, 1903, to continue the survey of the Arc of Meridian by connecting Mr. Simms' triangles immediately south of the Zambesi with the southern end of Lake Tanganyika. This work, so far as it is executed, is shown in the general map. An account of it is in course of preparation, and will form Volume VI. of the Geodetic Survey of South Africa.

Gordon's connection of the Transvaal and Rhodesian Geodetic Surveys.

There remained, however, on the Arc of the 30th Meridian, a gap between the Limpopo and the triangles in Southern Rhodesia, near Gwelo, which is explained by Mr. Rhodes' decision quoted at p. ix. I had strongly urged the Directors of the British South African Company to take advantage of the opportunity offered by the presence of a trained trigonometrical survey party in the neighbourhood to complete this link in the chain; but my efforts, at 6,000 miles distant from headquarters, were unavailing. I then appealed to Sir George Darwin, pointing out how comparatively simple it would be to complete the connection *now*, whilst a trained survey party was at hand, and how much more serious a business it would be to train and send out a party to do the work at a later date. The estimated cost of the work *now* was only £1,600, whilst it would cost at least double that sum to send out a special party at a later date. I begged him to lay the subject before the Directors of the British South Africa Company, representing the great importance of the work, as evidenced by the resolutions of the International Association of Scientific Academies, of the International Geodetic Conference, and of the British Association; but the reply (received in November, 1905) was:

> "For the present the Company feels itself restricted to absolutely necessary expenditure, and the matter, though not shelved altogether, had better stand over for a while."

Financial difficulties.

Matters could not be left in this state, and I begged Sir George Darwin, as the President of the British Association and British representative of the International Geodetic Commission, to ascertain whether funds could not be obtained elsewhere. Sir George was then on the point of leaving for America to attend the Franklin Commemoration, and proposed being absent from England from the 14th March to the 1st of May. On May 7th I received the following cable from him—

> "Money possibly forthcoming hold party together."
>
> DARWIN.

I cabled, as the result of telegraphic enquiries addressed to Colonel Morris in Pretoria, that a decision was necessary before May 24th.

On May 19th I received the following cable message:—

> "I have procured £1,600 for completion Survey. Can you guarantee it will be finished for this sum? Impossible obtain more."
>
> DARWIN.

Meanwhile I ascertained that whilst Captain H. W. Gordon, R.E., the officer selected, was still available for the work, "the delay had necessitated the return of all transport equipment which must be purchased *de novo*," and that unanticipated charges for railway transport in Rhodesia would be made. Subsequently the transport difficulty was to some extent overcome by the kind consent of the Council to allow all transport to be drawn from the Transvaal Government, especially the immunized animals; a fair valuation to be put upon all items on taking over and again on their return after completion of the work (estimated to last eight months); on returning the items the difference between the two valuations only to be charged.

On the 31st May I cabled through the B.S.A. Company:—

> "Tell Darwin, Transvaal has granted loan of transport. Morris and I believe can now finish connection for sixteen hundred pounds. Delayed reply explained by post. Cable immediate advance three hundred pounds."

On the 8th June I received from the Secretary of the B.S.A, Company, Cape Town, three hundred pounds and a copy of the following cable message:—

> "Inform Sir David Gill from Darwin £1,600 has been granted only provided he guarantees finish connection."

I cabled in reply:—

> "Gill accepts responsibility, Acts of God and the King's enemies excepted."

Thereafter the sum of £200 was placed to the credit of Captain Gordon at Bulawayo on the 1st of August, and on the first day of each succeeding month.

Sir George Darwin's intervention.

It remains to explain how the financial question was solved in England through the exertions of Sir George Darwin. The Royal Geographical Society was the first to come forward with a subscription of £100,—the largest sum that its finances at the time could muster; The Royal Society subscribed £300; Mr. Wernher, on behalf of the firm of Wernher & Bight subscribed £100, and Sir George Darwin himself offered, if necessary, to be responsible for £100. The British South African Company then, on Sir George Darwin's suggestion, agreed to give £800 provided that a like sum was raised by subscription and a guarantee given that the work would be completed for £1,600. Then the British Association offered £300, and I undertook the guarantee.

Finally, thanks to the fact that all the Government Railways concerned generously agreed to accept half-rates, and to the energetic and economical management of Captain Gordon, the work was completed, and the payment of a few pounds of excess cost was not exacted by the B.S.A. Company. An account of the work and its results will be found in the Appendix to the present introduction.

DAVID GILL.

APPENDIX.

TRIGONOMETRICAL CONNECTION BETWEEN THE PREVIOUSLY EXISTING GEODETIC SURVEYS IN THE TRANSVAAL AND SOUTHERN RHODESIA, ALONG THE MERIDIAN OF 30° E. LONGITUDE, EXECUTED BY CAPTAIN H. W. GORDON, R.E.

The operations in the field are sufficiently described in the following report addressed to Sir David Gill:—

"Sir,

"I have the honour to report the completion of the chain of triangulation establishing the geodetic connection between the Rhodesian Geodetic Survey and the great Trigonometrical Survey of the Transvaal. The observing party was organised in Pretoria at the end of the month of June, 1906. It consisted of myself in general charge, with one assistant, and an officer in charge of beaconing with eight attached natives.

The transport comprised two light spring wagons and two Cape carts with twenty-four mules. The vehicles and animals were ultimately divided equally between the headquarter and the beaconing parties.

The party entrained at Pretoria on July 6th and arrived at Bulawayo on the evening of the 9th. The field was taken on the 14th, the whole party proceeding to the district of Belingwe, in order to carry southward the preliminary reconnaissance from the three geodetic stations already chosen as the most suitable points of departure in the Rhodesian chain. These stations were Filibusi, Standesi and Weza.

The point Filabusi was somewhat difficult to locate, and, as time pressed and the other points were suitable, no time was wasted in further search. The points Standaus and Wedza were, however, readily found, and the reconnaissance was carried forward to the Transvaal border as rapidly as circumstances permitted. Great difficulty was experienced in obtaining a centre point for the closing figure at the southern end of the chain, owing to the rolling nature of the thickly bushed country and the impossibility of obtaining a view in any direction without extensive clearing. This point alone took nearly a month to fix, and consequently fully a month extra was required to complete the reconnaissance.

The Limpopo River was reached by the end of September, and connection was effected with the Transvaal points, Pont and Dogola. At this stage, the points having been selected and roughly located, the beaconing party returned northward on the work of beacon erecting. The headquarter party followed almost at once carrying out the instrumental observation.

By the end of December the beaconer had arrived at the original starting points, and trekked back to Pretoria, where he handed in his transport and equipment. Six weeks later the observations also were brought to a successful conclusion, thus completing the work of junction.

Returning to Bulawayo, the equipment of the headquarter party was disposed of by sale, and the party entrained for Pretoria, arriving on the 21st Jan., 1907.

The character of the country covered by the triangulation is extremely variable. The northern section comprises the hill district of Belingwe, consisting in formation of broken slates, bounded westward by the diorite range of the Donio, which traverses this portion of Rhodesia from North to South.

Passing southwards through the heavy granite country of the M'Patem, one emerges on the flat heavily bushed tract which stretches continuously to the heights of the Zoutpansberg in the Transvaal. In this last country the work of observation became very tedious and difficult by reason of the unsteadiness of the images produced by irregular refraction. The absence of roads and the density of the bush in this section gave rise to much difficulty and delay in the earlier work of the reconnaissance, the trouble being in no way lightened by the constant thick haze prevailing during the months of July and August as the result of the numerous grass fires incidental to that season. During November heavy rains began to fall, and continued intermittently to the close of the work. The total length of the measured chain is about 135 miles.

In view of the necessity for the most rigid economy the staff of heliographers, usually employed in this class of work, was dispensed with; the observations being made on opaque signals, it was found necessary to limit the length of the figural lines to an average of 20 miles. There were thus, including the four established points of the terminal lines, a total of sixteen points for occupation. Each beacon consists of a wooden pole guyed by wires vertically over a square iron pin leaded into the rock, and carrying at its top two discs, at right angles to each other and 3 feet in diameter. The instrument used was the 10-inch Repsoid theodolite, mounted in an observing hut of the type recently used in the Transvaal.

Pressure of circumstances necessitated limiting the instrumental work at each station to a series of measures on four arcs only; the zero reference point of the circle being successively placed about the divisions of 0°, 45°, 90°, and 135°.

The atmospheric conditions were found to be so invariably unfavourable in the early mornings, either by reason of the dense mists or by extreme unsteadiness, that operations were confined entirely to the evening period, commencing about 5 p.m. The accompanying plan shows the relative positions of the various points, as well as some of the simpler topographical features of the country traversed.

I have been able to confine the expenditure to the prescribed limit only by the generosity of, first, the Transvaal Government, to whom I have been indebted for the loan of the transport equipment, as well as to the Intercolonial Council for the temporary loan of the instruments; secondly, the Railway Companies, who allowed a rebate of half fares.

I was much aided in my work by the officials of the Chartered Company, who rendered me every possible assistance, and also gave me the services of a trooper, B.S.A.P., to aid in dealing with the natives, and in finding my way about.

I would also like to bring to your notice the whole-hearted manner in which I was assisted by my booker, Capt. E. Christie, and my beaconer, Mr. D. J. Young.

I have the honour to be, Sir,
Your obedient servant,
(Signed) H. W. GORDON,
Capt., R.E."

The work above described consists of a pentagon having the side Pont-Dogola common to it and to the northern triangle of the Geodetic Survey of the Transvaal, and a quadrilateral having the side Standaus-Wedza common to it and to a triangle of the previously existing Geodetic Survey of Rhodesia.

The two figures are connected by a single chain of triangles, as shown in the Plate.

In the reduction of the observations the pentagon and quadrilateral were first adjusted to geometrical consistency, and to each angle of the simple triangles was applied the usual correction $1/3\ (180^\circ + \epsilon - \Sigma)$.

These corrections are shown in the column "Figural Corrections"—Table I.

The "Circuit Corrections" in the same Table are those which, in the chain of single triangles, are necessary to reproduce geometrical consistency in the Sides Pont-Dogola and Standaus-Wedza. These corrections, which produce consistency between the independent Surveys of the Transvaal and Rhodesia are very small, as the logarithmic discordance of scale in feet only amounts to 0·0000005.

The vertical heights given in Table II depend on Captain Gordon's observations only, with Pont and Dogola as origin. The pentagon and quadrilateral have been treated as isolated figures, and the remaining chain of triangles has been adjusted by a simultaneous solution.

The reductions have all been made at the Royal Observatory, Cape of Good Hope, under the supervision of Mr. S. S. Hough, F.R.S., now H.M. Astronomer.

The Latitudes, Longitudes and Azimuths given in Table III were computed with the data of the Geodetic Survey of the Transvaal and Orange River Colony with the side Pont-Dogola as origin.

The agreement between the Scales of the two independent Surveys is remarkable, and indeed the circuit angle-corrections of Gordon's triangles would be absolutely negligible if the angles of his chain had only been recorded to the first decimal of a second of arc.

But there is a difference of 8″·87 in the orientation of the two systems, which may be in part due to cumulative error in the system of triangulation South of the Limpopo (although upon the whole the Geodetic and astronomical Azimuths are in good mean accord) and partly to local attraction at Salisbury.

The initial Azimuth of the whole system of triangulation south of the Limpopo is the Bearing of Zuurberg from Buffelsfontein near Port Elizabeth, whilst that of Mr. Simms' triangulation in Rhodesia depends on Astronomical Observations at Salisbury. The position of Salisbury, as astronomically determined, has been used as the origin of the Geodetic co-ordinates in Rhodesia, and the agreement of the independent Surveys in a Latitude and Longitude is as close as could be expected.

The vertical heights have been carried on from the system of the Survey of the Transvaal and show a considerable discordance from those of Mr. Simms' Survey. The latter depend upon the adopted height of the railway Benchmark at Bulawayo, as determined by the Railway Surveyors from Cape Town and Port Elizabeth, the former upon a geodetic levelling from the sea at Lorenzo-Marques to the Base-line terminals at Belfast and Kroonstadt.

The following Table gives a comparison between the results of the independent Surveys north and south of the Limpopo, at the points of their connection, Standaus-Wedza, by Captain Gordon's chain of triangles.

STANDAUS.		WEDZA.	
	Gordon-Simms.		Gordon-Simms.
	″		″
Latitude	3·503	Latitude	3·543
Longitude	0·602	Longitude	0·627
Bearing of Wedza	8·89	Bearing of Standaus	8·86
Height	38 feet	Height	42 feet

The adjustment for discordance of scale amounts only to 2·64 inches on the side Standaus-Wedza.

Table I.

GEODETIC CONNECTION BETWEEN THE TRANSVAAL AND RHODESIA SURVEYS.

TRIANGLES AND LOG LENGTHS OF SIDES.

Station.			Observed Angles.	Figural Correction.	Circuit Correction.	Seconds of Final Angle.	Spherical Excess.	Log Length of Side in English Feet.
			° ′ ″	″	″	″	″	
Pont	=	P	43 24 45·77	+0·56		46·33		5·0942720
Dogola	=	D	57 21 36·46	+0·78		37·24	4·41	5·1825111
M'Kwe Kwe	=	W	79 13 40·18	+0·66		40·84		5·2494385
Pont	=	P	30 26 59·94	+0·07		60·01		4·8881366
M'Kwe Kwe	=	W	63 2 6·73	−0·20		6·53	2·49	5·1333305
Tafel Kop	=	T	86 30 56·12	−0·17		55·95		5·1825111
M'Kwe Kwe	=	W	54 20 13·66	+0·18		13·84		4·8231759
Mabezibgwa	=	M	70 39 21·60	+0·17		21·77	0·99	4·8881366
Tafel Kop	=	T	55 0 25·07	+0·31		25·38		4·8267748
Ugulumbi	=	U	37 2 56·27	−0·53		55·74		4·8267748
M'Kwe Kwe	=	W	94 30 25·87	−0·39		25·48	1·32	5·0454778
Mabezibgwa	=	M	48 26 40·33	−0·23		40·10		4·9209049
Dogola	=	D	39 31 49·07	−0·38		48·69		4·9209049
M'Kwe Kwe	=	W	68 53 33·56	−0·26		33·30	2·29	5·0869566
Ugulumbi	=	U	71 34 40·48	−0·18		40·30		5·0942720
Jemembi	=	I	47 7 22·03	+0·34	+0·03	22·40		5·0454778
Ugulumbi	=	U	70 48 40·50	+0·34	−0·01	40·83	3·34	5·1556595
Mabezibgwa	=	M	62 3 59·79	+0·34	−0·02	60·11		5·1266874
Kubungwe	=	K	57 1 38·97	+0·07	+0·02	39·06		5·1556595
Mabezibgwa	=	M	51 3 12·64	+0·07	−0·03	12·68	4·27	5·1227630
Jemembi	=	I	71 55 12·45	+0·07	+0·01	12·53		5·2099429
Silamgwe	=	S	79 10 40·52	−0·09	+0·01	40·44		5·1227630
Kubungwe	=	K	48 39 54·76	−0·09	+0·02	54·69	2·50	5·0061161
Jemembi	=	I	52 9 27·49	−0·09	−0·03	27·37		5·0280183
Ikondonko	=	A	60 33 56·50	+0·50	+0·02	57·02		5·0280183
Silamgwe	=	S	67 40 2·69	+0·50	+0·01	3·20	2·25	5·0541791
Kubungwe	=	K	51 46 1·56	+0·50	−0·03	2·03		4·9831871
Igar	=	O	65 47 58·85	+0·25	+0·01	59·11		4·9831871
Ikondonko	=	A	66 15 6·88	+0·25	+0·02	7·15	1·63	4·9847115
Silamgwe	=	S	47 56 55·15	+0·25	−0·03	55·37		4·8938585
Utowa	=	O	53 52 18·21	+0·63	+0·02	18·86		4·8938585
Igar	=	G	49 24 24·84	+0·63	−0·02	25·45	1·33	4·8670507
Ikondonko	=	A	76 43 16·39	+0·63	−0·00	17·02		4·9748394
Belingwe	=	B	40 1 24·79	−0·11	+0·04	24·72		4·9748394
Utowa	=	O	76 52 25·68	−0·11	−0·02	25·55	2·84	5·1550632
Igar	=	G	63 6 12·70	−0·11	−0·02	12·57		5·1168405
Shamba	=	H	58 27 13·35	+0·37	+0·02	13·74		5·1168405
Belingwe	=	B	56 9 28·15	+0·37	−0·01	28·51	3·58	5·1056686
Utowa	=	O	65 23 20·97	+0·37	−0·01	21·33		5·1449292
Wedza	=	Z	56 3 46·86	−0·24		46·62		5·1449292
Shamba	=	H	54 46 33·73	−0·32		33·41	4·24	5·1382087
Belingwe	=	B	69 9 44·82	−0·61		44·21		5·1966561

TABLE I—*continued.*

Station.	Observed Angles.	Figural Correction.	Circuit Correction.	Seconds of Final Angle.	Spherical Excess.	Log Length of Side in English Feet.
	° ′ ″	″	″	″	″	
Standaus = N	146 21 48·53	−0·01		48·52		5·1960561
Shamba = H	20 32 2·70	−0·23		2·47	0·83	4·9982192
Wedza = Z	13 6 9·52	+0·32		9·84		4·8086518
Belingwe = B	26 47 37·42	−0·47		36·95		4·8086518
Standaus = N	77 58 49·29	−0·07		49·22	2·05	5·1449292
Shamba = H	75 13 36·43	−0·55		35·88		5·1402579
Wedza = Z	69 9 56·38	+0·08		56·46		5·1402579
Standaus = N	68 27 59·24	+0·06		59·30	3·02	5·1382087
Belingwe = B	42 22 7·40	−0·14		7·26		4·9982192

Table II.

VERTICAL HEIGHTS.

Stations.	Line.	Observed Difference of Height.	Figural Correction.	Adjusted Difference of Height.
Adjusted by the Transvaal Polygon.				
		Eng. Ft.	Eng. Ft.	Eng. Ft.
Pont—Dogola	P—D	+837·8	Fixed	+837·8
Dogola—M'Kwe Kwe	D—W	−823·1	+0·6	−822·5
M'Kwe Kwe—Pont	W—P	− 16·2	+0·9	− 15·3
		− 1·5	+1·5	0·0
Pont—M'Kwe Kwe	P—W	+ 16·2	−0·9	+ 15·3
M'Kwe Kwe—Tafel Kop ..	W—T	+160·1	+0·8	+160·9
Tafel Kop—Pont	T—P	−176·4	+0·2	−176·2
		− 0·1	+0·1	0·0
M'Kwe Kwe—Tafel Kop ..	W—T	+160·1	+0·8	+160·9
Tafel Kop—Mabezibgwa ..	T—M	+112·9	+0·6	+113·5
Mabezibgwa—M'Kwe Kwe ..	M—W	−274·6	+0·2	−274·4
		− 1·6	+1·6	0·0
Mabezibgwa—M'Kwe Kwe ..	M—W	−274·6	+0·2	−274·4
M'Kwe Kwe—Ugulumbi ..	W—U	− 22·2	−0·7	− 22·9
Ugulumbi—Mabezibgwa ..	U—M	+298·0	−0·7	+297·3
		+ 1·2	−1·2	0·0
Ugulumbi—M'Kwe Kwe ..	U—M	+ 22·2	+0·7	+ 22·9
M'Kwe Kwe—Dogola	W—D	+823·1	−0·6	+822·5
Dogola—Ugulumbi	D—U	−845·7	+0·3	−845·4
		− 0·4	+0·4	0·0

TABLE II—*continued.*

Stations.	Line.	Observed Difference of Height.	Figural Correction.	Adjusted Difference of Height.
Chain of Simple Triangles.				
		Eng. ft.	Eng. ft.	Eng. ft.
Ugulumbi—Mabezibgwa ..	U—M	+ 297·3	Fixed	+ 297·3
Mabezibgwa—Jemembi ..	M—I	+1090·5	+0·3	+1090·8
Jemembi—Ugulumbi	I—U	−1387·7	−0·4	−1388·1
		+ 0·1	−0·1	0·0
Mabezibgwa	M—I	+1090·5	+0·3	+1090·8
Jemembi—Kubungwe	I—K	− 630·4	+1·0	− 629·4
Kubungwe—Mabezibgwa ..	K—M	− 462·0	+0·6	− 461·4
		− 1·6	+1·6	0·0
Kubungwe—Jemembi	K—I	+ 630·4	−1·0	+ 629·4
Jemembi—Silamgwe	I—S	+ 100·0	−0·2	+ 99·8
Silamgwe—Kubungwe ..	S—K	− 729·5	+0·3	− 729·2
		+ 0·9	−0·9	0·0
Silamgwe—Kubungwe ..	S—K	− 729·5	+0·3	− 729·2
Kubungwe—Ikondonko ..	K—A	+ 594·0	+0·5	+ 594·5
Ikondonko—Silamgwe	A—S	+ 134·3	+0·4	+ 134·7
		− 1·2	+1·2	0·0
Silamgwe—Ikondonko	S—A	− 134·3	−0·4	− 134·7
Ikondonko—Igar	A—G	+ 513·6	−0·1	+ 513·5
Igar—Silamgwe	G—S	− 378·9	+0·1	− 378·8
		+ 0·4	−0·4	0·0
Ikondonko—Igar	A—G	+ 513·6	−0·1	+ 513·5
Igar—Utowa	G—O	+ 216·0	−1·1	+ 214·9
Utowa—Ikondonko	O—A	− 728·1	−0·3	− 728·4
		+ 1·5	−1·5	0·0
Igar—Utowa	G—O	+ 216·0	−1·1	+ 214·9
Utowa—Belingwe	O—B	+ 788·9	+1·8	+ 790·7
Belingwe—Igar	B—G	−1005·0	−0·6	−1005·6
		− 0·1	+0·1	0·0
Utowa—Belingwe	O—B	+ 788·9	+1·8	+ 790·7
Belingwe—Shamba	B—H	+ 85·0	Fixed	+ 85·0
Shamba—Utowa	H—O	− 878·0	+2·3	− 875·7
		− 4·1	+4·1	0·0
Adjusted by the Rhodesian Triangle.				
Belingwe—Shamba	B—H	+ 85·7	−0·7	+ 85·0
Shamba—Wedza	H—Z	− 684·2	−0·6	− 684·8
Wedza—Belingwe	Z—B	+ 601·2	−1·4	+ 599·8
		+ 2·7	−2·7	0·0

TABLE II—*continued.*

Stations.	Line.	Observed Difference of Height.	Figural Correction.	Adjusted Difference of Height.
Adjusted by the Rhodesian Triangle—continued.				
		Eng. ft.	Eng. ft.	Eng. ft.
Wedza—Belingwe	Z—B	+ 601·2	—1·4	+ 599·8
Belingwe—Standaus	B—N	— 822·6	—0·6	— 823·2
Standaus—Wedza	N—Z	+ 224·2	—0·8	+ 223·4
		+ 2·8	—2·8	0·0
Standaus—Wedza	N—Z	+ 224·2	—0·8	+ 223·4
Wedza—Shamba	Z—H	+ 684·2	+0·6	+ 684·8
Shamba—Standaus	H—N	— 908·2	—0·0	— 908·2
		+ 0·2	—0·2	0·0

Table III.

FINAL RESULTS.

PONT = P.

	° ′ ″	
S. Lat.	22 15 13·513.	Height above M.S.L.
E. Long.	29 9 47·191.	2072·5 Eng. ft.

Station.			Bearing.	Log Length of Line, English Feet.
			° ′ ″	
Tafel Kop	=	1	196 6 25·82	5·1833305
M'Kwe Kwe	=	W	226 33 25·33	5·1825111
Dogola	=	D	269 58 12·16	5·2494385

DOGOLA = D.

	° ′ ″	
S. Lat.	22 15 9·539.	Height above M.S.L.
E. Long.	29 41 17·683.	2910·3 Eng. ft.

Station.			Bearing.	Log Length of Line, English Feet.
			° ′ ″	
Pont	=	P	89 46 16·23	5·2494385
M'Kwe Kwe	=	W	147 7 53·47	5·0942718
Ugulumbi	=	U	186 39 42·16	5·0869566

TABLE III—*continued.*

M'KWE KWE = W.

S. Lat. 21° 57′ 54″·958. Height above M.S.L.
E. Long. 29 29 21·381. 2087·8 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Pont = P	46 26 8·90	5·1825111
Tafel Kop = T	109 28 10·48	4·8881366
Mabezibgwa = M	168 48 24·27	4·8267748
Ugulumbi = U	258 18 49·76	4·9209049
Dogola = D	327 12 28·06	5·0942718

TAFEL KOP = T.

S. Lat. 21° 53′ 39″·146. Height above M.S.L.
E. Long. 29 16 27·624. 2248·7 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Pont = P	16 3 55·34	5·1838305
Mabezibgwa = M	234 32 34·01	4·8231759
M'Kwe Kwe = W	289 32 59·39	4·8881366

UGULUMBI = U.

S. Lat. 21° 55′ 7″·015. Height above M.S.L.
E. Long. 29 43 48·189. 2064·9 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Dogola = D	6 38 45·57	5·0869566
M'Kwe Kwe = W	78 13 25·87	4·9209049
Mabezibgwa = M	115 16 21·61	5·0454778
Jemembi = I	186 5 2·44	5·1266874

MABEZIBGWA = M.

S. Lat. 21° 47′ 16″·254. Height above M.S.L.
E. Long. 29 26 2·815. 2362·2 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Tafel Kop = T	54 29 0:08	4·8231759
Kubungwe = K	182 15 45·37	5·2099429
Jemembi = I	288 18 58·05	5·1556595
Ugulumbi = U	295 22 58·16	5·0454778
M'Kwe Kwe = W	348 49 38·26	4·8267748

Table III—*continued.*

JEMEMBI = I.

° ′ ″
S. Lat. 21 33 7·749.
E. Long. 29 46 18·486.

Height above M.S.L.
3453·0 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Ugulumbi = U	6 4 6·76	5·1266874
Mabezibgwa = M	53 11 29·16	5·1556595
Kubungwe = K	125 6 41·69	5·1227680
Silamgwe = S	177 16 9·06	5·0061161

KUBUNGWE = K.

° ′ ″
S. Lat. 21 20 30·401.
E. Long. 29 27 10·533.

Height above M.S.L.
2823·6 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Mabezibgwa = M	2 15 20·48	5·2099429
Ikondonko = A	204 47 44·70	5·0541791
Silamgwe = S	256 38 46·78	5·0280188
Jemembi = I	305 13 41·42	5·1227680

SILAMGWE = S.

° ′ ″
S. Lat. 21 16 23·754.
E. Long. 29 45 27·399.

Height above M.S.L.
3552·7 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Kubungwe = K	76 27 8·16	5·0280188
Ikondonko = A	144 7 11·36	4·9831871
Igar = G	192 4 6·78	4·9847115
Jemembi = I	357 16 27·72	5·0061161

IKONDONKO = A.

° ′ ″
S. Lat. 21 3 30·915.
E. Long. 29 35 32·128.

Height above M.S.L.
2418·1 Eng. ft.

Station.	Bearing.	Log Length of Line, English Feet.
	° ′ ″	
Kubungwe = K	24 44 43·31	5·0541791
Utowa = O	181 12 22·13	4·8670507
Igar = G	257 55 39·14	4·8988585
Silamgwe = S	324 10 46·29	4·9831871

TABLE III—*continued.*

IGAR = G.

	° ′ ″	
S. Lat.	21 0 48·035.	Height above M.S.L.
E. Long.	29 49 0·437.	3931·6 Eng. ft.

Station.			Bearing.	Log Length of Line, English Feet.
			° ′ ″	
Silamgwe	=	S	12 2 49·88	4·9847115
Ikondonko	=	A	77 50 48·99	4·8938585
Utowa	=	O	127 15 14·44	4·9748394
Belingwe	=	B	190 21 27·01	5·1550632

UTOWA = O.

	° ′ ″	
S. Lat.	20 51 21·312.	Height above M.S.L.
E. Long.	29 35 48·468.	4146·5 Eng. ft.

Station.			Bearing.	Log Length of Line, English Feet.
			° ′ ″	
Ikondonko	=	A	1 12 16·30	4·8870507
Shamba	=	H	165 4 10·56	5·1056686
Belingwe	=	B	230 27 31·89	5·1168405
Igar	=	G	307 19 57·44	4·9748394

BELINGWE = B.

	° ′ ″	
S. Lat.	20 37 34·603.	Height above M.S.L.
E. Long.	29 53 30·925.	4937·2 Eng. ft.

Station.			Bearing.	Log Length of Side, English Feet.
			° ′ ″	
Igar	=	G	10 19 50·87	5·1550632
Utowa	=	O	50 21 15·59	5·1168405
Shamba	=	H	106 30 44·10	5·1449292
Standaus	=	N	133 18 21·05	5·1402579
Wedza	=	Z	175 40 28·81	5·1382087

SHAMBA = H.

	° ′ ″	
S. Lat.	20 30 59·699.	Height above M.S.L.
E. Long.	29 30 2·767.	5022·2 Eng. ft.

Station.			Bearing.	Log Length of Side, English Feet.
			° ′ ″	
Standaus	=	N	211 20 23·04	4·8086513
Wedza	=	Z	281 52 25·51	5·1966561
Belingwe	=	B	286 38 58·92	5·1449292
Utowa	=	O	345 6 12·66	5·1056686

TABLE III—*continued.*

STANDAUS = N

	° ′ ″	
S. Lat.	20 21 54·699.	Height above M.S.L.
E. Long.	29 35 54·599.	4114·0 Eng. ft.

Station.			Bearing.	Log Length of Line, English Feet.
			° ′ ″	
Shamba	=	H	31 18 20·14	4·8086513
Wedza	=	Z	244 56 31·62	4·9982192
Belingwe	=	B	313 24 30·92	5·1402579

WEDZA = Z.

	° ′ ″	
S. Lat.	20 14 55·891.	Height above M.S.L.
E. Long.	29 51 42·042.	4337·4 Eng. ft.

Station.			Bearing.	Log Length of Line, English Feet.
			° ′ ″	
Shamba	=	H	51 44 52·97	5·1966561
Standaus	=	N	64 51 2·81	4·9982192
Belingwe	=	B	355 41 6·35	5·1332037

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Report on the Trigonometrical Survey of the Transvaal and Orange River Colony.

INTRODUCTORY.

1. The general scheme for a continuation of the Geodetic Survey is contained in correspondence which passed between the High Commissioner and Sir David Gill, H.M. Astronomer at the Cape, and is definitively laid down in the High Commissioner's instructions to the Superintendent of the Survey, dated 14th October, 1902; in his letter to Sir David Gill, dated 18th May, 1903; and in Sir David Gill's letter to the Superintendent, dated 26th September, 1903.

Geodetic scheme.

2. The Geodetic Scheme above referred to comprised the following, namely :—

A. Extension of the arc along the 28th meridian southwards through Basutoland to join the existing Cape chain of triangles near Cala in Cape Colony (No. 7 below).

B. Extension of the Longitude arc from Wepener eastwards through Basutoland to connect with the existing chain in Natal.

C. Extension of the Longitude arc through Kroonstad from Newcastle to the coast.

D. Extension of arc along the 30th meridian from the Limpopo to existing triangulation in Rhodesia, in the neighbourhood of Gwelo.

Work to be done in Transvaal and Orange River Colony.

3. The scheme was based on what was proposed to be done in the new Colonies, in which the following chains of Primary Triangulation were to be run, namely :—

No. 1. From Kimberley through Kroonstad eastwards to Natal, connecting work already existing in the neighbourhood of Kimberley with that at Newcastle.

No. 2. Hopetown to Wepener, starting from existing work near Orange River Station in the Cape Colony and proceeding eastwards to connect with No. 7 below.

No. 3. From Belfast to Ottoshoop, connecting the northern terminal of No. 4 below with the chain along the 30th meridian.

No. 4. From Kimberley to Ottoshoop, an extension of the chain of previous work terminating at Kimberley, northwards.

No. 5. From Ottoshoop through the Waterberg to the Limpopo, a northward extension of No. 4.

No. 6. Newcastle, along the 30th meridian, through Belfast to the Limpopo, a portion of the arc of meridian from the Cape to Cairo.

No. 7. From Pretoria, southwards through Kroonstad and Basutoland, to Cala in Cape Colony, along the 28th meridian, connecting No. 3 above with the existing chain through Griqualand East and the Transkei.

No. 8. A short tie-chain connecting No. 4 with No. 7.

Exceptions.

4. The foregoing chains (paragraphs 2 and 3) have all been included in the work with the exception of No. 5, but nothing has been done as regards the extension of No. 1 to the sea coast, nor of No. 2 to join the Natal arc. The work involved in D (paragraph 2) is being executed under the direct control of Sir David Gill, and the field work, by Captain H. W. Gordon, R.E., is now completed.

New survey based on old.

5. The work of the Transvaal and Orange River Colony Survey is practically an extension of the Primary Triangulation of the Cape and Natal, executed during the years 1883-93, and, although the new work could have stood alone, yet, for obvious reasons, it has been included with the old in one

general reduction, with the limitation, however, that the quadrilaterals of chains of the old work have been taken as fixed, and have not, therefore, suffered any change as a result of the reductions.

Diagram of the triangulation.

6. The whole of the triangulation chains in South Africa are shown in Diagram I. The portion coloured pink represents work done in Natal and the Cape; that coloured yellow represents work just completed in the Transvaal and Orange River Colony; the portion uncoloured represents Sir Thomas Maclear's work.

Lengths of chains.

7. The lengths of the several chains, which include the portions common to two that meet, are—

A. Chains in Transvaal and Orange River Colony:—

	Miles.
Kimberley through Kroonstad to Newcastle	335
Hopetown to Wepener	185
Belfast to Ottoshoop	300
Kimberley to Ottoshoop	240
Newcastle through Belfast to the Limpopo	410
Pretoria through Basutoland to Cala ...	440
Chain connecting No. 4 with Nos. 1 and 7	100

B. Accessory chains, used in the reductions:—

Port Elizabeth to Newcastle	600
Port Elizabeth to Kimberley	415

C. Cape and Natal Survey chains:—

Port Elizabeth to Caledon	425
Hanover to Calvinia	300
Oudtshoorn to Fraserburg (tie-chain) ...	120

D. Sir Thomas Maclear's chain:—

Cape Point to Calvinia	250

E. Summary, total lengths:—

	Miles.
Chains in Transvaal and Orange River Colony ...	2,010
Accessory chains	1,015
Cape and Natal Survey chains	845
Sir Thomas Maclear's chain	250
Grand Total ...	4,120

Comparison between old and new survey.

8. The table below gives the comparison between the old work and the new.

	New.	Old.	Totals or Averages.
Number of years taken to complete	4½	10¼	14¾
Total mileage of chains	1867	1620	3487
Area of chains in square miles	60,718	62,447	123,160
Average breadth of chain	32·5	38·5	35·3
Number of triangles	178	133	311
Average area of triangles (square miles)	341	470	396
Length of longest line	69·9	101·3	—
Average length of line along chains	24·6	30·9	27·1
Approximate total cost	£72,000	£50,000	£122,000
Cost per square mile	24*s.*	16*s.*	19*s.* 9*d.*
Cost per mile of chain	£39	£31	£35

NOTE.—Total mileage (line 2) excludes portions common to junctions of chains.

Number of triangles (line 5) includes only the triangles used in computing the area.

It is to be noted, in the above comparison, that the chain from Kimberley to Ottoshoop crosses a stretch of very flat country, and that, as a consequence, the number of trigonometrical points is large in proportion to the length of the chain, as well that the lines are short. If this chain be neglected, the figures for the two surveys approximate much more closely, except as regards cost.

Cost of survey distributed.

9. The total cost of the survey has been, as nearly as possible, £72,000, which includes deductions for sums realised by sales of transport and general equipment.

The area covered by the triangulation is :—

	Square Miles.
Transvaal	32,601
Orange River Colony	20,588
Cape Colony	3,210
Natal	1,000
Basutoland	3,314
Total	60,713

The shares of the total cost, as above, on the basis of area covered, would be :—

	£
Transvaal	38,662
Orange River Colony	24,415
Cape Colony	3,806
Natal	1,186
Basutoland	3,931*
Total	72,000

But as there was no agreement with either the Cape Colony or Natal that they should participate in this primary work, and as the present survey has made considerable use of pre-existing work in both, there is no question of their having to bear any portion of its cost.

Sites of base lines.

10. In conjunction with the triangulation chains it was decided to measure base lines at or near the following places :—

a. Belfast } on the 30th meridian.
b. Limpopo }
c. Ottoshoop, western limit of Transvaal, on the 26th meridian.
d. Kroonstad, junction of chains Nos. 1 and 7 (paragraph 3), near the 27th meridian.
e. Wepener, eastern limit of Orange River Colony, on the 27th meridian.

All the above, except the Limpopo base, are located as stated. With regard to the latter, it was found that the difficulties of every kind associated with the country bordering on the river quite precluded the selection of a site so far north, and, instead, a base was measured along the Houts River, through the centre of Malitzi's location.

Availability of base lines previously measured.

11. In addition to the foregoing base lines measured in the Transvaal and Orange River Colony, there are available the base lines measured in the Natal-Cape Colony survey, at Kimberley and Maritzburg, the former near the 26th and the latter on the 30th meridian. In other words, the survey of the Transvaal and Orange River Colony, in the general reduction of its results, makes use of results previously obtained in Cape Colony and Natal to the extent of two base lines and over 1,000 miles of triangulation chain.

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* There is no doubt that Basutoland's share of the cost is out of all proportion to the practical advantages of the work done there. The mountainous nature of the country permitted the use of very long lines, so that only five points are fixed therein. It is considered that a sum of £3,000 fully covers the value of the work done, and this sum has been credited to survey funds. Their share in proportion to the number of points fixed as compared with the total number in the survey is £2,000. Their contribution of £3,000 is very near the mean between this and their share in proportion to area covered by triangulation as given above.

Comprehensive reduction of South African chains.

12. Strictly speaking, for the most accurate results, the whole of the chains comprising the two surveys should have been included in one general discussion. But it was clearly not a work which could have been thrown on the Transvaal and Orange River Colony alone, and it was not to be expected that the Cape and Natal would participate in further primary work when, for all practical purposes, that had already been completed some ten years ago. (See paragraph 5.)

Selection of Belfast base.

13. The detail of work first considered was the measurement of a base line in the neighbourhood of Belfast on the 30th meridian; and a small party was sent there to make the necessary reconnaissance. In the course of this work four different sites for a possible base line of about 12 miles in length were reported on, the choice eventually falling on one which best fulfilled the conditions, namely that which had its south terminal close to the monument at Belfast, and its north terminal in the direction of Verloren Vlei.

Temporary Head-quarter camp.

In the meanwhile, during the months of November and December, 1902, the necessary camp and transport equipment was being collected and packed at a temporary camp on land close to Mr. Mackenzie's farm, about four miles out of Pretoria. The site was very suitable in every respect, and specially in an assured water supply and a minimum of risk from horse sickness. At this camp were delivered the horses, mules, carts, and other transport equipment, as well as tents, cooking utensils, etc., for use in camping in the field.

Services of officers and non-commissioned officers, R.E.

14. Negotiations were carried on with a view to obtaining the services of two officers of the Royal Engineers for the reconnaissance work on the triangulation chains, and a third to have charge of an observing party so soon as a sufficient number of points had been selected and beaconed in advance. The services, also, of four non-commissioned officers of the Royal Engineers were applied for as heliographers to the observing officer. The remainder of the personnel required as assistants to the various officers in charge of parties in the field were civilians obtained in the Colony.

Appointment of Messrs. Robinson and Simms.

15. It has been of great advantage to the survey that it was able to secure the services of Messrs. W. B. Robinson and A. Simms. These gentlemen had not long previously been engaged on the survey in Rhodesia, where they gained considerable experience in the measuring of base-lines with the Jaderin wire apparatus, and applied that experience successfully in their new work. Mr. Simms eventually had charge of an observing party in the field; and Mr. Robinson had charge of the computing office. The survey was further fortunate in obtaining the services of three of the computing staff of the Royal Observatory, Cape Town. They rendered good service during the base measurements, and subsequently as computers.

Work of the Royal Engineer officers.

16. Reconnaissance work under Lieutenants King and Dunman, R.E., was started towards the end of January, 1903. The base-line staff was completed by the end of June, the preliminaries of laying out the line, sectioning, and rough measuring having been previously completed. The observing officer, Captain Gordon, R.E., with his party complete, started for Newcastle in July to commence observing on the chain of triangles to Belfast, so that by the end of that month all the work of the survey, with the exception of the levelling from Mean Sea Level, had been satisfactorily, if somewhat tardily, started. The levelling work was not entered upon till August, 1904.

Superintendent's party.

17. The Superintendent's party then became free to proceed on its own mission of selecting the sites for the four remaining base lines, and, subsequently, of taking the necessary Astronomical Observations.

Chronology of chief events.

18. The sequence of the most important items indicating the progress of organising and starting the work in its earlier stages is conveniently given in the chronology below:—

1902.

Nov. 3. Officer appointed Superintendent of the survey reached and reported at Pretoria.

1903.

Jan. 1. Mr. W. B. Robinson taken on the strength as Chief Computer.

Jan. 15. Reconnaissance officers Lieuts. W. A. de C. King and T. N. Dunman, R.E., reported for duty.

Jan. 26. Equipment of reconnaissance parties completed, and they entrained for Newcastle to commence work, proceeding northwards to Belfast.

Feb. 3. Mr. Robinson and party entrained for Belfast to select a base-line site in that neighbourhood.

Mar. 21. First consignment of instruments, ordered from England in November, 1902, through the Crown Agents, reached Pretoria.

Mar. 28. Final decision come to as regards base-line site at Belfast.

Apr. 11. Capt. H. W. Gordon, R.E., reported for duty.

Apr. 18. Entrained 60 mules to Belfast.

Apr. 24. Struck camp at Mackenzie's Farm. Headquarters entrained for Belfast, which became, for the time being, an assembling and a collecting centre.

May 19. Repsold Theodolite and Jaderin wire apparatus arrived in camp.

June 11. Four non-commissioned officers, R.E., arrived, to act as heliographers to Captain Gordon.

June 28. Mr. Simms reported for duty, and took over responsible charge of the camp and the measurement of base lines, assisted temporarily by Mr. Robinson and a staff of twelve civilians.

July 18. Captain Gordon's party started from Belfast for Newcastle, proceeding by road.

Aug. 12. Superintendent's party started for Ottoshoop to select the site for the base line.

Aug. 21. The measurement of Belfast base completed, and the party entrained for Ottoshoop, *viâ* De Aar and Mafeking.

Sept. 5. The base line at Ottoshoop selected and laid out.

Sept. 6. Base measuring party reached Ottoshoop.

Sept. 10. Superintendent's party left Ottoshoop for Wepener, Orange River Colony, entraining at Pretoria for Bloemfontein, and thereafter by road.

Oct. 18. Site of base line at Wepener selected and laid out.

Oct. 23. Base measuring party completed the measurement of the Ottoshoop base and left for Wepener, entraining at Mafeking for Bloemfontein and Thabanchu, and thereafter proceeding by road.

Nov. 23. Selection of site for the Kroonstad base completed, and the line laid out.

Nov. 24. Superintendent's party returned to Pretoria.

From this date onwards the movements of the various parties are more conveniently referred to in the separate reports on their work.

RECONNAISSANCE.

19. The reconnaissance of the country for the selection of points for the triangulation chains was most satisfactorily and expeditiously carried out by Lieuts. King and Dunman, and subsequently by Capt. C. H. Ley, R.E. The work these officers performed is given in the chronology below :—

Chronology of parties. Lieut. King.

20. *Lieut. King.*

1903.

Jan. 26. Entrained at Pretoria with Lieut. Dunman for Newcastle.

Mar. 29. Reached Belfast (200 miles) with Lieut. Dunman, and completed the selection of stations in that neighbourhood together.

1903.

May 26. Started on reconnaissance alone to select points of a chain to the Limpopo.

July 30. Reached the Limpopo (250 miles), selected points in the neighbourhood, reported unfavourably on the possibilities of a base-line site, and continued his reconnaissance for a chain of points across the Waterberg towards Zeerust and Ottoshoop.

Nov. 1. Completed his work in the neighbourhood of Rustenburg (250 miles) and returned to Pretoria en route for further work, and to refit.

Nov. 14. Started southwards from Pretoria to select points of the chain through the Orange River Colony and Basutoland to Cape Colony.

1904.

Apr. 2. Completed his work at Lubisi in Cape Colony (500 miles).

Apr. 9. Returned to Pretoria to complete his report.

Apr. 29. Left for England on completing his work.

His work consisted in reconnoitring and selecting the stations along 1,200 miles of chain.

21. *Lieut. Dunman.* **Lieut. Dunman.**

1903.

Jan. 26. Entrained at Pretoria with Lieut. King for Newcastle.

Mar. 29. Reached Belfast (200 miles) with Lieut. King.

May 26. Started on reconnaissance alone, to select points of a chain proceeding westward to Ottoshoop.

Sept. 15. Completed this work (300 miles), and continued towards Kimberley, experiencing considerable difficulty in selecting suitable points across a flat, waterless country, and running several tentative lines.

1904.

Mar. 10. Joined by Capt. Ley, R.E., and working together, abandoned the direct route to Kimberley from Ottoshoop.

Apr. 21. Completed selection of points for a chain between Kroonstad and Kimberley, having separately and in conjunction with Capt. Ley reconnoitred some 350 miles of country.

Apr. 30. Started with Capt. Ley on reconnaissance of a chain between Hopetown and Wepener.

June 7. Completed the work at Wepener (220 miles).

June 14. Returned to military duty in South Africa on completion of his report.

His work consisted in reconnoitring and selecting the stations along 1,070 miles of chain.

22. *Captain Ley.* **Capt. Ley.**

1903.

Oct. 30. Reported for duty at Pretoria.

Nov. 12. Entrained with his party for Newcastle to select the points of a chain thence to Kroonstad.

1904.

Feb. 23. Completed this work and reached Kroonstad (200 miles).

Mar. 10. Joined Lieut. Dunman at Hoopstad.

Apr. 21. In conjunction with Lieut. Dunman completed the work of selection to Kimberley (150 miles).

Apr. 30. Started with the same officer on the chain between Hopetown and Wepener (220 miles).

1904.
June 8. Returned to Pretoria on completion to refit and receive instructions for further special work.
July 7. Commenced the reconnaissance of the chain between Kimberley and Ottoshoop (250 miles).
Nov. 10. Returned to Pretoria to make preparations for beaconing and observing this chain.

His work consisted in reconnoitring and selecting the stations along 820 miles of chain.

Exceptions.

23. It will be noticed that a great many more miles of chain were reconnoitred than have been included in the completed work of the survey. But very early in the work it was decided for economical reasons to omit the chain across the Waterberg between the Limpopo and Rustenburg, and to discard a number of points which were fixed in the neighbourhood of Kroonstad.

Parties combined at start.

24. It was advantageous to start Lieuts. King and Dunman to work together between Newcastle and Belfast, so that they might train their assistants, gain some experience of the county and its possibilities, and learn from their co-operation in reconnaissance work how better to carry it on when separated. Their civilian assistants had had no previous experience of such work, no particular knowledge of the topography of the country, and only became really helpful by the time the parties separated at Belfast.

Instructions issued.

25. All necessary instructions for the conduct of the work and safeguarding the health of the party and its equipment were issued to the parties before they took the field. These are, generally, contained in the following extracts :—

A. The general principles underlying the selection of the trigonometrical points may be stated as follows :—

The angles of all triangles should be as nearly as possible 60°, and the sides not less than 30 miles or exceeding 50 miles. If nothing better can be done, their length may go to 60 or even 70 miles. No angle of a triangle should be less than 40°, unless a quadrilateral or polygonal figure can be completed between adjacent points.

B. The selection of the actual site where the beacon is to be erected at a trigonometrical point is an important consideration, The best is a rock foundation, and this should always, if possible, be selected to receive the iron pin serving to permanently mark the point.

C. On every trigonometrical point selected some form of temporary beacon should be erected, in order that the point may be recognised and distinguished from others as the work is proceeded with.

D. Every trigonometrical point should be sketched, and reported on as follows :—

Water supply at foot of mountain and on summit.
Site for a camping ground, preferably close to water.
Nature of approaches to the point from the nearest road.
Nature and height of ascent.
Labour to be obtained in the neighbourhood.
Position of the nearest farm or farms where supplies of food and forage can be obtained.
Distance and direction of nearest offices—post, telegraph, magistrate, and native commissioner.
An outline sketch of the distant country, showing the positions of other trigonometrical points visible, and to assist in recognising points ahead which offer themselves for selection.

E. The trigonometrical points should be given their local names, or as found on the maps supplied; and as each point is finally selected and left behind, with its temporary beacon, the name should be left clearly marked on a piece of paper fastened to the base of the pole, and enclosed by a pile of stones.

F. Every care should be taken of the horses and mules, under the general instructions issued regarding them. Instructions are also issued as regards the care of the personnel.

G. A careful diary should be kept of each day's work, to form the basis of the reports you are required to furnish. All accidents should be entered, and every incident that has a bearing on the health and efficiency of the party, or that might be of importance to the beaconing and observing party to follow.

H. You must exercise your discretion as to trekking at night, preferably moonlight nights, rather than in the day-time. Otherwise, the best time for trekking is the early morning and late evening, that is, from dawn for three hours, and for three hours before sunset, six hours in all, during which you may expect to cover thirty miles on an average road.

I. Detailed instructions were issued on the mode of drawing up a scheme for occupation of the trigonometrical points by the several fractions of the observing party, similar, in all respects, to those issued on the Cape-Natal Survey, and epitomised in the report on that work. The advantages of the scheme are fairly obvious, and its effective operation has been proved in the course of the present work.

J. The information collected by the reconnaissance officers was formulated as a report intended eventually for use of the observing party and its heliographers. But before it reached them, it was first sent to the beaconing party, following in its wake, for its use, enabling it to make sure of the points to be beaconed, and to travel by the best and shortest roads from one point to another. The beaconing officer, in his turn, corrected, amplified, or supplemented the information where necessary, and then forwarded the report to the observing officer, who thus became possessed of accurate information upon which to base his movements. The information proved of the greatest possible service in removing all uncertainty as to the best routes to take, as to the condition of the roads and approaches to the points, and possibilities of obtaining supplies of food and forage.

K. As a guide to the reports which had to be rendered on trigonometrical points, the following illustrative reports were issued to reconnaissance officers. They give all necessary information in a concise form.

TRIGONOMETRICAL POINT: HLATENKUNGU.

Illustrative reports.

General Description.—A conspicuous flat-topped mountain, just N. of the Umtwalume River, and close to the sources of the Ifafa.

Beacon.—On the highest point of the mountain.

Water.—There is no water on the summit except in shallow pools in the rock after rain. The nearest water is at a spring issuing from a rock on its eastern face, about 400 feet below summit. It rarely fails except in extreme drought. A perceptible track leads down to it, leaving the eastern escarpment in a direction by compass 77 degrees, and distant from the beacon about 400 yards. A pole has been erected indicating this point.

Camping Ground.—The best camping ground for the main party is at foot of the mountain, on its western side, where water is abundant both from a spring and in the dam below, on Mr. Stewart's farm, who can provide both forage and the ordinary food supplies.

Ascent.—The ascent from the farm to the beacon is somewhat steep and rough in places, but presents no real difficulty for the carriage of the instruments. Mr. Stewart will supply natives to assist in this, charging 5*s.* for each native for the trip up and down. There are fully 40 natives available, The height to be climbed is 2,300 feet. The observing party will have to camp on the summit, on the grassy part near the edge of the bush which comes up to the edge of the table.

Firewood.—Firewood is plentiful everywhere.

Post Office and Telegraph Office.—The nearest telegraph and magistrate's offices are at Ixopo, distant 15 miles. The nearest post office is at High Flats, distant 4 miles, but Mr. Stewart has a roadside bag which is emptied daily at 9 a.m.

Roads.—The road from the Ixopo to Umzinto passes round the northern end of the mountain and bends southwards to pass close to the farm. The roadway is generally good. The shortest way to this trigonometrical point from Richmond is by Springvale, and distance 35 miles. From Mabehlan, by Ixopo, distance 45 miles. From Hancock's Drift over the Umzimkulu, by the Umzinto road, 40 miles.

Compass Bearings—

Hluku ...	...	252 degrees.
Malowe ...	...	293 „
Mabehlan ...	...	330 „
Drake's Hill	...	37 „
Inkunye ...	...	59 „

TRIGONOMETRICAL POINT: MABEHLAN.

General Description.—This is a difficult point from nearly every point of view. It is a flat-topped mountain with kranzes 30 to 40 feet high all round, and the slopes leading up to the foot are covered with large boulders which make climbing somewhat laborious. The mountain is on the south bank of the Umkomanzi R., about fourteen miles below the drift, and distant from this river fully ten miles. The road to the point from the main road over the drift is distinctly bad, crossing several deep dongas with bad approaches, and the greater part of the track (it is not a road) is very stony. Still with care it is passable, and it brings you to within two miles of the foot of the hills.

Beacon.—The beacon is practically in the centre of the table top on which or near which there is no water.

Camping Ground.—The only possible camping site is close to the road, directly opposite the mountain; there is a spring at the foot of the mountain on that side, with a small natural reservoir at which horses could be watered, and from which *water* will have to be brought for drinking purposes in camp.

Ascent.—The height to be ascended is about 1,500 feet. There is no track, but the ascent can be made anywhere, although the actual line recommended is clearly marked by poles with small white flags.

The observing party will have to camp on the summit, and fetch water from the spring below.

Firewood.—The supply of firewood is very scanty, but sufficient if the kaffirs are sent out to collect it.

Labour.—Labour for the ascent will have to be brought from Mr. Thornton's farm at the drift. His charges are 7*s.* 6*d.* for each native for the trip up and down. He can supply with his own and neighbouring farms up to 30 or 35. He has plenty of mealies, but no other form of forage, and can supply mealie meal for the natives.

Post Office and Telegraph Office.—The nearest telegraph and magistrate's offices are at Ixopo, distance 50 miles. The nearest post office is at Mr. Thornton's, distance 14 miles.

Compass Bearings—

Zwartkop	... ...	54 degrees.
Table Mountain	...	100 „
Drake's Hill	... ...	180 „
Byrnetown	... ...	257 „

In the instructions actually issued, no detail was considered too trivial to refer to, and to this, and to the zeal and ability of the officers entrusted with this most important portion of the work, may be attributed the satisfactory selection of the chains and the rapidity with which the reconnaissances were completed.

Transport Equipment.

26. The equipment of the reconnaissance parties consisted at first, for one party, of a two-wheeled open cart on springs, five mules, three horses, and three natives, each officer having one civilian assistant. But it was soon found that the single cart was insufficient, owing to the frequent necessity for carrying supplies of forage, and it was replaced by a short buck wagon on springs, requiring five additional mules.

Instruments.

27. Each party was further provided with—

1 Aneroid Barometer
1 Prismatic Compass
1 Telescope
2 Field Glasses
2 5-in. Heliographs
1 Watch
1 Circular Protractor

and the necessary maps, notebooks, multiple copying books, drawing paper, etc.

Cost of the Reconnaissance.

28. The total cost of the work of reconnaissance has been as nearly as possible, £8,358, which includes all items of expenditure, but excludes sales. For this the number of points fixed has been 187, representing ten times that number of miles of chain, at a cost per point of £44 13s. 11d.

BEACONING.

Beacon employed.

29. The form of beacon generally erected is the same in every respect as of those erected during the Cape-Natal Survey, 1883-93, and fully described and illustrated in the report. Essentially, they consist of an iron pipe, 8 ft. long, surmounted by four semicircular discs of sheet-iron at right-angles to each other, so that these present a regular figure varying from a circle to an ellipse from whatever point they are viewed. The foot of the iron pipe fits over the rounded head of an iron pin, leaded into rock or set in concrete as the permanent mark of the station. The pipe is guyed to the ground by means of iron pegs, and a pile of stones protects both guys and piping in a substantial manner, The discs and piping are painted a dull black, and the name of the station is stencilled on the discs in white paint.

Beacon special to chain Kimberley to Ottoshoop.

30. This form of beacon, erected along all the chains, the points of which are situated on high mountains or at places not frequented by irresponsible people, was fairly safe from injury or displacement. But for the chain from Kimberley to Ottoshoop, which crosses a flat county, where such beacons would be too conspicuously seen, and easily approached by the casual person, a concrete pillar four feet high was substituted as the permanent mark. The theodolite was placed upon this pillar centrally over the axis of the galvanized iron tube described in paragraph 31, To define the station for observation from other points, a wooden pole, surmounted by wooden discs, was inserted in the tubing. The pole and discs were, therefore, removable.

Concrete Mould.

31. The concrete pillars above referred to were erected expeditiously and accurately with the help of an iron form (see photo. No. 16), consisting of four semi-cylinders, separable for convenience of transport, but capable of being fastened together to make up a hollow cylinder, four feet high and with an

internal diameter of 1 ft. 10 in. This was firmly set up over the selected point on the ground, and was filled with concrete, the interior having been previously greased to prevent the cement adhering to the sides. To make room for the pole of the beacon, a four-foot length of galvanized iron tubing was set up centrally inside the iron mould, and held in position, while the latter was being filled, by cross arms, on the top of the mould, which had a circular hole to take the top of the tube. The foot of the tube was held firm by an iron pin in the ground, over which it fitted.

Cost of Concrete Pillar prohibitive for general use.

32. It would have been of the greatest advantage to have had this form of beacon erected generally, but the cost of transporting cement, sand, and stone was quite prohibitive for any but a flat country and where the points could be reached by carts. The concrete pillars served as a firm support for the instrument, independent of all weather changes, whereas the wooden portable tripod generally used was, naturally, not so reliable.

Chronology of parties.

33. Four beaconing parties were eventually organised, and the work they performed is given, for each party, separately below.

S. B. Morgenrood.

Party under charge of Mr. S. B. Morgenrood.

1903.

Jan. 11. Taken on strength of the Survey.

Jan. 26. Entrained for Newcastle with Lieutenants King and Dunman, and started beaconing along the chain towards Belfast so soon as the first few points had been selected.

June 6. Completed to Baatjes Bult, and reported at Belfast, having beaconed 12 points.

1904.

Feb. 9. Continuously employed in the beaconing round Belfast, and thence along the chain to Ottoshoop, and completed at Pretoria, having beaconed 12 more points. Twice held up in low veld by horse-sickness.

May 27. Completed beaconing of a further 8 points towards Klerksdorp. (Most of these were subsequently discarded. See paragraph 23.)

June 8. Left Pretoria for Quaggafontein, 73 miles N.W. of Belfast, and continued the beaconing through the bushveld towards Ottoshoop.

Aug. 4. Completed this work, having beaconed 10 points, and returned to Pretoria. Concreted 3 points in neighbourhood of Belfast, where the ground was soft, and returned to Pretoria.

Aug. 22. Proceeded to the trigonometrical points near Thabanchu to report on the manner in which the beacons had been erected by Mr. Middleton, returning to Pretoria on completion.

Sept. 17. Left by train for Zastron, on report of Mr. Simms, to take over beaconing from Mr. Middleton, and completed beaconing of his remaining 6 stations.

Dec. 13. Returned to Pretoria.

Dec. 21. Discharged on completion of his work and reports.

In all, Mr. Morgenrood erected beacons at 48 stations.

J. F. Gill.

34. *Party under charge of Mr. J. F. Gill.*

1903.

July 17. Taken on strength of Survey and placed in charge of the camp at Mackenzie's farm.

Nov. 12. Entrained for Newcastle to beacon the points of the chain thence towards Kroonstad, following Captain Ley's reconnaissance.

1904.

Apr. 17. Completed the above, beaconing 8 points, and returned to Pretoria.

1903.

May 2. Entrained for Belfast to commence on the chain to the Limpopo, and beaconed a further 13 points.

Aug. 15. Returned to Pretoria to write up his report.

Sept. 2. Entrained for Kroonstad and started the beaconing on the chain to Kimberley and beaconed 14 points.

Dec. 2. Returned to Pretoria to complete report and hand in equipment.

Dec. 21. Discharged on completing his work.

In all, Mr. Gill erected beacons at 35 points.

35. *Party under charge of Mr. C. de C. Middleton.*

C. de C. Middleton.

1904.

Jan. 12. Taken on strength of Survey.

Jan. 25. Started on the beaconing of points along the chain from Pretoria southwards through Basutoland to the Cape Colony.

Sept. 24. Completed beaconing as far as the neighbourhood of Zastron, and was there relieved by Mr. S. B. Morgenrood, returning to Pretoria.

Oct. 20. Completed his report and was discharged.

In all, Mr. Middleton erected beacons at 27 points.

36. *Party under charge of Mr. C. E. Ezzey.*

C. E. Ezzey.

1903.

Jan. 15. Taken on strength of Survey, acted as conductor to various parties, and was in charge of transport in camp at Belfast.

1904.

Aug. 25. Entrained for Edenburg, *en route* for Hopetown, to beacon the
Oct. 21. chain thence to Wepener. Beaconed 12 points and returned to Pretoria on completion.

Dec. 20. Entrained for Smaldeel, proceeding thence by road to Boshof to beacon the chain between Kimberley and Ottoshoop.

1905.

Apr. 25. Completed the above work, beaconing 47 points by the erection of concrete pillars, and returned to Pretoria,

May 5. Entrained for Kroonstad, *en route* to select points of a chain to connect the triangulation in that neighbourhood with the chain between Kimberley and Ottoshoop. Selected and beaconed five points.

June 19. Returned to Pretoria on completion of above.

July 31. Completed his reports and was discharged.

In all, Mr. Ezzey erected beacons at 64 points.

37. Beacons have been erected by :

Summary.

	Points.
No. 1 party at	48
,, 2 ,, ,,	35
,, 3 ,, ,,	27
,, 4 ,, ,,	64
Total	174
Add 11 base-line terminals	11
Deduct 5 points discarded	5
Total	180 stations.

38. The beaconing parties were instructed fully as regards the form of the beacons to be erected, and as to the care necessary in ensuring that the pin was firmly fixed in the ground as the permanent mark of the station, and

Instructions as to beacons.

that the beacon was accurately and firmly erected and safe-guarded by a considerable pile of stones. For verticalising the iron piping representing the pole of the beacon, an iron level was provided.

General instructions.

39. Instructions similar to those issued to the reconnaissance officers were issued to the beaconing parties as regards signalling, care of the animals and of the transport and camp equipment, and health of the personnel. These are given later on in this report under the several headings.

Equipment.

40. The equipment of a beaconing party consisted of one open two-wheeled cart on springs, 5 mules, 1 horse, and three natives, except that the party under charge of Mr. Ezzey, which had to erect concrete pillars, had one trolly wagon, one open two-wheeled cart, carrying a cask for water, 15 mules, 2 horses and four natives. Each party carried :—

1 magnetic compass,
1 pair field glasses,
1 watch,

with a supply of stationery.

Cost of Beaconing.

41. The total cost of the beaconing has been £5,780. The total number of points beaconed being 174, the cost for each point is £33 4*s.* 4*d.*

OBSERVING.

42. For some considerable time only one party was observing in the field—the party under Captain Gordon—which, as already stated, commenced its work at Newcastle towards the end of July, 1903. Its work and movements were as shown below :—

Chronology of Captain Gordon's party.

1903.	
July 25.	Commenced observing at Salt Lake in Natal.
1904.	
Mar. 2.	Reached neighbourhood of Belfast and observed at points in vicinity, proceeding thence westwards along the chain to Ottoshoop.
July 11.	Reached neighbourhood of Pretoria, to find that the dense haze of grass fire smoke quite precluded any observations over the long lines, and decided to trek to Ottoshoop and start observing at that terminal of the chain.
July 30.	Reached neighbourhood of Zeerust.
Oct. 24.	Completed the chain and returned to Pretoria, and refitted.
Nov. 11.	Started by road for Thabankulu in Natal to commence work on the chain, between Newcastle and Kroonstad.
1905.	
Mar. 6.	Reached Kroonstad.
Mar. 11.	Continued his observations thence towards Kimberley.
May 19.	Completed his work at Scholtzkop, in Cape Colony.
May 26.	Started from Kimberley, proceeding by road, to Orange River trigonometrical point (Cape Colony).
May 28.	Commenced observing at that point, and proceeded thence along the chain to Wepener.
July 23.	Completed his observations at Jammersberg, and commenced his return journey.
Aug. 5.	Reached Pretoria.
Aug. 25.	Transferred to the Swaziland Survey to run a chain of points from the Transvaal chain in neighbourhood of Carolina due eastwards to the Portuguese boundary.

1906.

Feb. 1. Rejoined the Trigonometrical Survey, and commenced the reconnaissance, beaconing, and observing of a subsidiary chain of points along and related to the primary line between Cable Hill and Observatory Hill, Johannesburg.

April 3. Completed the above, and returned to Pretoria, where he was engaged in writing up his report, and in preparing a descriptive list of the whole of the points on the survey.

July 1. Transferred for completing the work on a chain connecting the Limpopo terminals of the Transvaal arc with existing triangulation in the neighbourhood of Gwelo (Rhodesia).

Work done.

43. Captain Gordon's party is responsible for the work of observing along the chains as follows :—

Chain.	Miles of chain.	No. of points.	Months to complete.	Points per month.
Newcastle to Belfast	170	19	14	2·4
Belfast to Ottoshoop	300	15		
Newcastle to Kroonstad	130	11	6	4·7
Kroonstad to Kimberley	205	17		
Hopetown to Wepener	185	14	3	4·7
	990	76	23	3·3
Cable Hill to Observatory	34	14	2	7·0
Totals	1,024	90	25	—

The last item above is not a part of the primary triangulation, but may be classed as secondary. Reference to this is made hereafter (paragraph 147).

Climatic conditions.

44. Captain Gordon's party was singularly unfortunate as regards the atmospheric conditions during the earlier stages of his work, as may be seen from the table above, in that whereas he took 14 months to complete the first 34 points, he only took six months to complete the next 28, and three months over the last 14 points of his primary work. The disabilities arose out of the prevailing dense haze of grass-fire smoke, which was also found to be a very serious obstacle to progress in Natal. On the other hand, progress along the chains in Cape Colony was almost monotonously rapid owing to its general freedom from this nuisance.

Mr. Simms' party.

45. It was not till the measurement of the base lines was completed that the second observing party became available under charge of Mr. Simms, in July, 1904. The base-line party was reorganised and equipped for the new work during that month. The work and movements of the party were as follows :—

1904.

Aug. 15. Commenced observing in the neighbourhood of Pretoria along the chain southwards through the Orange River Colony and Basutoland to Cape Colony.

1905.

June 10. Completed the above and entrained at Indwe station (Cape Colony) for Pietersburg (Transvaal), proceeding thence by road to the Limpopo to start work on the chain between the river and Belfast.

1906.

Jan. 10. Completed the above and returned to Pretoria, entraining at Belfast.

Feb. 28. Completed his reports, and was discharged.

Work done.

46. Mr. Simms' party is responsible for the work of observing along the chains below :—

Chain	Miles of chain.	No. of points.	Months to complete.	Points per month.
Pretoria, through Basutoland, to Cape Colony	440	39	10	3·9
Belfast to the Limpopo	240	18	7	2·6
Totals	680	57	17	3·4

Conditions of country.

47. It may be said of this party that it had average luck in the weather, but it had more physical exertion to go through in having many high points to climb, at first through Basutoland and the N.E. districts of Cape Colony, and eventually along the ranges of mountains running north from Belfast. In the former, one point is over 10,000 feet above sea level, three over 9000, and six over 8000. The high points were occupied in the summer and autumn seasons. It is doubtful whether their ascents would have been practicable during the winter.

Capt. Ley's party.

48. Reference has been made (paragraph 21) to the unsuitability of the country lying between Kimberley and Ottoshoop for laying down a primary triangulation through it, and it became necessary to run a chain of a secondary order to connect these two base lines. The work was entrusted to Captain Ley, and he very skilfully and expeditiously selected the points, superintended the beaconing, and completed the necessary observations, as given below (*see* paragraph 22 for his previous history) :—

1905.

Jan. 6. Having reorganised and equipped his party, and being furnished with a Repsold theodolite for his observations, started for Boshof (O.R.C.), entraining at Pretoria for Smaldeel, and proceeding thence by road.

July 4. Completed his work at Zeerust and returned upon his tracks to commence observations of the tie-chain, Driekuil towards Kroonstad.

Aug. 28. Completed the above and returned to Pretoria, entraining at Smaldeel. Wrote up his reports and handed in all his equipment.

Nov. 4. Embarked for England to return to military duty.

Work done.

49. Captain Ley's party is responsible for the work of observing along the chains below :—

Chain.	Miles of chain.	No. of points.	Months to complete.	Points per month.
Kimberley to Ottoshoop..	240	51	6	8·5
Driekuil to Kroonstad	100	12	2	6·0
Totals	340	63	8	7·9

Conditions of country.

50. This party had the easiest task to perform. There was no ascent of elevated points, in nearly every case they could be approached with carts, but his observations were limited to the hour or two just preceding sunset, when the air was steadiest for observing. Moreover, as will be referred to later on, he only took half the observations set down for the two primary parties to make.

Summary. 51. A summary of the observing work shows that a total length of 2010 miles of chain have been observed, containing 196 points, of which 20 are common to meeting or crossing chains, and that on the average four points were completed per month.

Repsold theodolite. 52. The foregoing observations, with the exception of the special chain of points referred to in paragraph 43, were all taken with a Repsold 10-inch theodolite, which is figured and described in the report on the Survey of the Cape and Natal; and the results obtained prove the great value of the instrument for geodetic and trigonometrical purposes (see photos. Nos. 1, 2, 3, 4, 23, and 24). It was always protected and screened from the sun and wind by an enclosing hut, strong, light, and easily portable, similar in construction to that used on the previous survey, 1883–93, and fully described and figured in the report on that work. The instrument was ordinarily mounted for the observations on a portable wooden stand, stiffened by iron braces (see photo. No. 9), also described in the above report. The canvas roof-cover of the hut (see photo. No. 20) was made in one piece for the terrestial observations; in two pieces, allowing an opening a foot in width, for astronomical observations. Neither as regards the hut or the stand did the further experience of their use in the field necessitate any change in their construction.

Arc zeros. 53. Captain Gordon and Mr. Simms observed at all points of their work with the zeros of the horizontal arc set as follows :—

		°			°
Arc 1	C L	0	Arc 5	C L	23
	C R	180		C R	203
Arc 2	C R	270	Arc 6	C R	293
	C L	90		C L	113
Arc 3	C L	45	Arc 7	C L	67
	C R	225		C R	247
Arc 4	C R	315	Arc 8	C R	337
	C L	135		C L	157

not, of necessity, accurately to the foregoing, but in their near proximity; and whenever any particular arc had to be repeated, either as a whole, or partially, the circle readings for that arc as recorded were always adhered to. The reference direction in all cases was, as nearly as could be determined, the true south line at each point. The instructions to the observer were to observe half the arcs in the early morning and the remainder in the late afternoon, as being the hours of the day when the air might be expected to be clearest and steadiest. But it was soon found that to observe strictly in this way would be the cause of considerable delay when the morning observations were frequently quite prevented by mist and haze. The vertical angles were all observed in the afternoon as near to sunset as possible, and in repetition equivalent to the first pair of arcs as for horizontal angles, the readings of the vertical arc level being always recorded.

Use of theodolite. 54. The eyepiece of the theodolite is provided with a micrometer with a number of fixed wires for astronomical observations and a movable wire. In the observations of the horizontal angles, a number of bisections of the heliograph light, or beacon, were made, depending on their steadiness and definition in the field of view, the separate readings being recorded in the field book. The watch telescope of the instrument was always set on some convenient mark near at hand, and the readings of its micrometer were recorded in a similar way. These records, with the readings of the micrometers of the horizontal circle and of the plate level, represented the complete observation of a point on one of the arcs. The values of a revolution of the sight and watch telescopes were determined from time to time and recorded, the general procedure being the same as adopted during the Cape-Natal Survey.

Suggested limit to accuracy. 55. Reference is fully made in Mr. Robinson's report to the results of the observations of the horizontal and vertical angles, and to the method of adjusting the errors in the complex figures in the triangulation, and the circuits of chains for errors of closure. The resulting probable error of the measurement of a horizontal angle is much the same as was found in the previous survey of the Cape and Natal. It would seem, therefore, as if a limit to accuracy in such observations, with the class of instrument used and under the conditions of climate and atmospheric clearness and steadiness prevailing in South Africa, has been reached. It is to be observed that the whole of the work of both old and new surveys has always been done under pressure of saving both time and money; that no experimentation of any kind was ever possible; and that all observations have been strictly limited to the actual nececessities of a trigonometrical survey. It is thought that the general results of both surveys, although indicative of work of a high class, cannot pretend, for the reasons stated, to be of the highest class possible, which can only be reached when time and money do not enter into the considerations.

Special observations.

56. A satisfactory method of including in the round of observations a distant station which was frequently being obscured by mist or grass-fire smoke was to set up a signal, usually a straight rod, two inches in diameter and painted white, at a distance from the observing point of between 2 and 3 miles, and, as nearly as possible, in the vertical of the distant station. This rod was regarded as the distant station, and included in the usual round of observations. The beacon at the latter was then referred to the rod, at suitable opportunities, by means of the micrometer of the observing telescope, by simple vertical movement of the latter. It was in this way that the station at Verloren Vlei was dealt with at Mare's Kop and Langekloof, when persistently obscured by grass-fire smoke for the better part of every day.

Work organisation of observing parties.

57. The observing party was organised and equipped much in the same way as was done on the Cape-Natal Survey, and consisted of the headquarter, or the actual observing, party and four heliograph parties, each provided with an 8-inch heliograph to contend with the longest lines of the chains. The heliographs served two purposes: in defining the points for observation, and as a means of communication between the several parties. In showing light at one point to another, the heliograph was carefully placed in the exact line between the pole of the beacon and the distant point, the former not being interfered with in any way by a heliographer. The beacon was, however, removed by the observing party and reinstated on completion of the observations.

Arc zeros (Capt. Ley).

58. The foregoing refers to the parties under charge of Captain Gordon and Mr. Simms. Captain Ley had no heliographers; the beacons on the short lines of his chain were easily visible without such assistance, especially as he always used the highest power eyepiece in his theodolite. In his work the four first arcs only of those given in paragraph 53 were used. It was originally intended to regard his chain as purely "secondary," because of the shortness of the lines, and to observe with an 8-inch Troughton & Simms theodolite specially ordered from England for the purpose. But as that instrument, although ordered on the 2nd July, 1904, did not reach Pretoria till 2nd March, 1905, it was replaced by a 10-inch Repsold available. Captain Ley's observations are, therefore, of the same class as those of the other observing parties.

Instructions.

59. Instructions were issued in detail to the observing parties, governing the work of observing as referred to in paragraphs 53 and 54, in addition to those relating to the care of the personnel and equipment. The officers in charge were particularly directed never, under any circumstances, to leave the the Repsold theodolite mounted in the observing hut at night time, or when they were not in the immediate vicinity of the hut.

Equipment.

60. The equipment of the three parties was as follows:—

A. *Captain Gordon.*

Transport	2 Cape carts, with hoods. 6 Cape carts, open (4 for helio parties). 40 mules (20 for helio parties). 4 horses.

Instruments
1 Repsold theodolite with portable hut and stand.
1 prismatic compass.
4 pocket dials (for helio parties).
1 telescope.
5 field glasses (4 for helio parties).
5 8-inch heliographs (4 for helio parties).
1 5-inch heliograph.
1 pocket aneroid.
3 watches.
1 sidereal chronometer.

B. *Mr. Simms.*

Transport
1 Cape cart, with hood.
5 Cape carts open (4 for helio parties).
1 wagon (in previous use on base lines).
36 mules (16 for helio parties).
2 horses.

Instruments
1 Repsold theodolite with portable hut and stand.
4 prismatic compasses (helio parties).
2 chronometers (1 sidereal, 1 mean).
4 field glasses (helio parties).
3 8-inch heliographs.
6 5-inch heliographs (4 for helio parties).

C. *Captain Ley.*

Transport
1 trolley wagon.
1 Cape cart, open.
1 buggy (for transport of theodolite).
17 mules.
2 horses.

Instruments
1 Repsold theodolite with portable hut and stand.
1 prismatic compass.
1 telescope with tripod stand.
1 field glass.
2 5-inch heliographs.
1 steel tape.

Personnel.

61. The personnel of the two primary parties consisted, each, of:—

1 conductor.
1 clerk and booker.
1 assistant booker.
4 heliographers.

Captain Ley had one civilian assistant, and one civilian beaconer under his orders.

Cost of observing.

62. The total cost of the observing has been £25,448, excluding sales; the number of points observed, 185. The average cost per point is, therefore, £137 11*s.* 2*d.* The cost of reconnaissance, beaconing, and observing of the secondary chain connecting Cable Hill and Observatory Hill is £436.

BASE LINES.

Heads of information.

63. It will be convenient to give the essentials of information for each of the base lines as follows:—

A. Position of terminals, with their latitude and longitude.
B. General direction of line, as running from south or west terminal.
C. Length of base and number of sections.

D. Heights of terminals above mean sea level.
E. Mean height of line above mean sea level.
F. Average gradient.
G. Measurement commenced.
H. Measurement completed.
K. Jaderin wires used.

Belfast base.

64. *Belfast Base.*—In the preliminary reconnaissance for the selection of a site for this line, four suitable sites were examined, only one of which fulfilled generally the conditions laid down, especially as regards proximity to a permanent water supply and to a centre for the supply of food and forage, with a minimum of risk to the animals from horse sickness. The country round Belfast is not at all suitable for base-line sites; it is far too hilly, and bleak and cold during the winter months, and liable to storms of high wind and rain; and it was, perhaps, unfortunate that the first base line of the survey was not measured under more favourable conditions.

The information for the Belfast base is—

A. South terminal close to the Monument on farm Steynplaats (339).* North terminal on farm Moelijkheid (776).

South terminal	Lat. S. 25° 40′. Long. E. 30° 4′.	North terminal	Lat. S. 25° 30′. Long. E. 30° 4′.

B. North.
C. 11·8 miles, with 8 sections.
D. South terminal, 6391·4 ft. North terminal, 6605·4 ft.
E. 6326 ft.
F. 1 in 35.
G. July 1, 1903.
H. August 21, 1903.
K. Nos. 1 and 3, invar.

Ottoshoop.

65. *Ottoshoop Base.*—This base line proved to be the easiest to measure of the whole series. The great difficulty was the water supply—the only permanent source near a suitable site was within the village lands on the Malmani River, and this practically determined the selection.

A. South terminal on farm Kareebosch (108). The North terminal on farm Doornfontein (289).

South terminal	Lat. S. 25° 48′. Long. E. 25° 58′.	North terminal	Lat. S. 25° 40′. Long. E. 25° 55′.

B. N.N.W.
C. 10·8 miles, with 8 sections.
D. South terminal, 4733·3 ft. North terminal, 4689·9 ft.
E. 4690 ft.
F. 1 in 112.
G. September 11, 1903.
H. October 23, 1903.
K. Steel, A/18 for two complete measures, and No. 3, invar, for third measure.

Wepener base.

66. *Wepener Base.*—At the time this base was selected, a severe drought was prevailing in the district, and as it was not possible to say how long it might last, it was considered essential that the line should be run as close as possible to the Caledon River. Fortunately the country was favourable in every other respect.

A. South terminal on farm Workshop (97). North terminal on farm Waterford (99), and near Caledon River and bridge.

South terminal	Lat. S. 29° 55′. Long. E. 27° 3′.	North terminal	Lat. S. 29° 44′. Long. E. 26° 59′.

B. N.N.W.

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* The numbers in brackets are the register numbers of the farms.

C. 13·5 miles, with 6 sections.
D. South terminal, 5251·6 ft. North terminal, 4802·7 ft.
E. 4879 ft.
F. 1 in 57.
G. Nov. 15, 1903.
H. Jan. 15, 1904.
K. No. 3, invar.

Kroonstad base.

67. *Kroonstad Base.*—The same difficulty as regards water supply presented itself in the selection of a site for this base line as happened at Ottoshoop and Wepener. The parts of the country most favourable for the actual measurement were completely waterless and inconveniently far removed from a supply centre. The best line that offered necessitated crossing the Valsch River, which was spanned by one of the longer Jaderin wires, compared before and after use with the usual measuring wire.

A. West terminal on farm Tweedronk (783). East terminal on the Town Lands of Kroonstad, and distant about 5 miles from the town.

West terminal	Lat. S. 27° 35'.	Long. E. 27° 1'.	East terminal	Lat. S. 27° 37'.	Long. E. 27° 13'.

B. E. by S.
C. 12·3 miles, with 6 sections.
D. West terminal, 4692·2 ft. East terminal, 4691·7 ft.
E. 4547 ft.
F. 1 in 49.
G. Jan. 28, 1904.
H. Apr. 30, 1904.
K. No. 3, invar.

Houts River base.

68. *Houts River Base.*—It was the intention, at first, to measure a line somewhere in the close vicinity of the Limpopo, at the most northerly point of the Transvaal; and the officer reconnoitring in that neighbourhood was instructed to report on favourable sites. It proved, however, that there were too many objections. There was no water to be found anywhere except in the river, no near source of food supply, the country is thickly covered with bush, and is dangerous both on account of malaria and horse sickness. The despatch of a large party of men and animals into such conditions appeared to be too risky and expensive. The site eventually selected was much further south.*

A. South terminal on farm Vaalkop (813). North terminal on farm Kalkbank (128).

South terminal	Lat. S. 23° 52'.	Long. E. 29° 14'.	North terminal	Lat. S. 23° 34'.	Long. E. 29° 20'.

B. N.N.E.
C. 21·1 miles, with 8 sections.
D. South terminal, 4658·4 ft. North terminal, 3707·2 ft.
E. 3991 ft.
F. 1 in 78.
G. May 27, 1904.
H. June 30, 1904.
K. No. 1, invar, except a small portion of the first measure, when No. 3, invar, was used.

Alignment.

69. The alignment of the sectional points of the base lines at Ottoshoop, Wepener, and Kroonstad was carried out by means of a special telescope of three inches aperture and 36 inches focal length, with an eyepiece fitted with cross wires and mounted on the Y's of a 10-inch theodolite by Troughton and Simms. With this aperture and a magnification of 100 diameters, all the sectional points were clearly seen in the late afternoon from one terminal of the line. But the halfway point was first carefully fixed, and the remainder

---

* The site of this base line was selected by Mr. Simms.

aligned between it and the terminals. There could have been no error in the alignment exceeding one inch. Such accuracy was not perhaps necessary, but the power of the instrument greatly expedited the work.

Reports.

70. In accordance with the general intention expressed in the covering letter to this report, the full details of the procedure in, and the results of, the measurements of the base lines is contained in the reports, separately furnished, of the four persons chiefly concerned in the work, namely :—

A. Mr. Simms, responsible for the general conduct of the work, who has detailed the procedure of the whole, discussed the various points which have arisen as the measurement progressed, and furnished the final results.

B. Mr. Cochrane, responsible for the levelling work, representing what was needed in accuracy in the vertical plane.

C. Mr. Gummer, responsible for the alignments of the successive tripods, representing what was needed in accuracy in the horizontal plane.

D. Mr. Banks, responsible as the measurer at one terminal of the Jaderin wire (Mr. Simms at the other), representing what was needed in accuracy along the line itself.

These four reports practically cover the whole ground of measurement, and show that four skilful and careful men, at least, are absolutely necessary for ensuring successful work.

Jaderin wire apparatus.

71. The Jaderin wire apparatus, as originally received, consisted essentially of (see photos. Nos. 17, 18, 19 and 29) :—

A. The Jaderin wires of nickel-steel and brass, the brass and steel together forming a metallic thermometer, in lengths of 80 feet for the general measurement, and longer lengths up to 240 feet for special occasions. The actual wires received and available for use are as follows :—

80 ft. Nos. 1, 3 and 5, invar.
Nos. A_{17}, A_{18}, A_{19}, A_{20}—2nd class nickel-steel.
Nos. 2, 4, and 6, brass.

160 ft. No. 7, 3rd class nickel-steel.
No. 8, brass.

240 ft. No. 9, 3rd class nickel-steel.
No. 10, brass.

For the purpose of the ground standards referred to later on (paragraph 141), the wires below were cut down :—

No. 5, invar, to 75 ft. Cape.
No. A_{20}, 2nd class
No. 2, brass to 50 ft. Cape.
No. 7, 3rd class
No. 8, brass to 150 ft. Cape.

The numbers A_{20} and 2 are, however, on No. 2 and A_{20} wires respectively, so that now A_{20} is a brass wire, and No. 2 the measuring wire.

B. Levelling instrument.

C. Levelling staff.

D. Ten tripods (numbered from 0 to 9).

E. Two spring balances to extend the wires under a given pull; one reading to tenths of kilogrammes for the preceding end; the other, to single kilos., for the following end.

F. Aligning telescope to fit on the tripods.

But the items in B, C, E, and F were discarded as unsuitable or unreliable, and a Cooke reversible level, a specially graduated levelling staff, and a free-wheel allowing of a constant tension to wires by the suspension of weights of

10 kilos at each end, replaced them from the commencement of the work. The free-wheel is figured in photographs Nos. 11 and 12. It allowed of free movement to the wire in the line of measurement.

71 (*a*). It is great matter for regret that, on a final inspection of the Jaderin wires before handing over, it was found that No. 3 Invar was broken while lying coiled in the box. The three Invar wires (non-expanding), of which the broken wire is one, are not of continuous material throughout, but consist of two lengths of wire joined together. Originally the wires were made in lengths of less than 80 feet, probably in lengths of 20 metres (65·62ft.), and the additional portions were either welded or soldered on. The break has occurred at a distance of 8 ft. 9 in. (=2·667 M.) from the end, and almost at the centre of a part of the wire where the silver plating of the wire has scaled off. But as this plating has also gone from other parts of No. 3, and much to the same extent on No. 1, the break is probably due either to specific weakness or to defective joining. These wires have seen a good deal of service in the field during the base measurements; but, in spite of the greatest care, it has not been possible to prevent the plating from peeling off, and the process still continues. That this is due to exposure to the sun and air is proved by the fact that No. 5 Invar, which has hardly been used at all, shows no signs of this defect. It is strongly recommended that the broken wire should be sent to Messrs. Ahlberg and Ohlsson, Instrument Fabrik, Sibyllegaten, 10, Stockholm, for repair, with a request that information should be furnished (1) as to the distance from one end at which the two pieces of the wire joined, (2) as to the probable cause of the fracture, (3) as to the scaling off of the plating, its cause and remedy. From a careful inspection of the broken ends of the wire, there is strong reason for attributing the fracture to defective joining if the junction was made at the distance from the end above given, or to defective material if otherwise.

The wires are contained in a box marked "Jaderin Apparatus Wires," and the broken wire has a tag attached to it marked "No. 3 Invar."

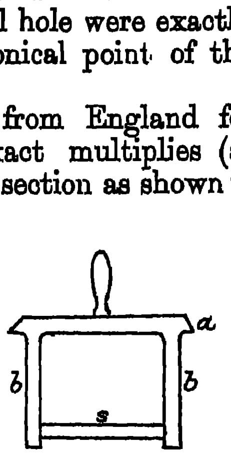
It may be of interest to Messrs Ahlberg and Ohlsson, and perhaps of assistance in their answering the above questions, to know that the broken wire has measured over 100 miles of base line.

Terminal marks.

72. The terminals of the base lines were marked by brass blocks, set in concrete, in the centre of which was let a small cyclinder of gold with a pinhole to represent the actual point. Lines are drawn through the pinhole along the brass surface at right angles to each other, one being in the alignment of the base. A supplementary conical hole is drilled, centred to the line at right angles to the alignment, and distant from the pinhole one-third of an inch, to receive the conical end of the rod of the transferring apparatus. Precautions were taken that the centres of the pinhole and the conical hole were exactly in the line at right angles to the alignment, and that the conical point of the rod was free from metallic touch.

Increment measurer.

73 A special steel bar* was ordered and received from England for measuring increments where the base lines were not exact multiplies (as rarely happened) of 80ft. It is made of steel, with a cross section as shown in the sketch. To give the divided edge rigidity, stiffening rods (S) are fixed, one near each end and five others at equal distances. It has a length of two metres, and is graduated on one inclined edge, as (*a*) in figure, to decimetres, with the last division in centi. and millimetres. Holes are drilled in the sides, *b b*, to enable the bar to be fixed to the camels of the bar apparatus. In this way it can be adjusted and moved as if it were one of the bars in position. The coincidences between lines on bars and transferring apparatus were made or read by a magnifying glass. The scale is marked "Standard at 62° Fah.," and allowance is made for expansion or contraction in reference to this temperature.



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* This bar, designed by Mr. Simms, was not, however, used during the base line measurements, but only in the measurements for the Ground Standards referred to in para. 141.

It would have been better if both the first and last decimetre divisions had been similarly divided, so that the coincidence of the reference end might might have been made by the observer turning the tangent screw of the camel for himself.

Remarks.

74. There is no doubt that when work is first started with the Jaderin wires the results are disappointing, or, in other words, that the expectation of accuracy is not great. If this should prove to be the experience in other countries where the system is adopted, it is better to train the base-measuring party up to the point at which confidence is established before anything is recorded as the actual measurement. Otherwise the first base would always be less accurately measured than others to follow, besides that the principle is bad of considering as final that upon which experience has been gained. There is all the more reason for this treatment of the case, in that the cost of measuring the base is small compared with the accuracy which can be obtained. With the Jaderin wires, a fairly long line of triangulation can be measured directly, whereas this line was only reached in the old days of steel bars and short base lines by the intervention of expanding triangulation.

Reflections.

75. The results of the base measurements are eminently satisfactory, speaking well for the skill and ability of the officer in charge and his subordinates. But there is no doubt whatever that neither skill nor ability would have produced the results were it not that ground standards were always laid down by means of the bar measuring apparatus which was used for measuring the base lines of the Cape-Natal Survey. These bars represented portable standards of length with which the wires could be compared systematically as the base measurement progressed, and which gave full indication of variations of length. It would be of no use to have the standards laid down at one place and carry on the base measurement at another. The "Standard" bars should always form an integral part of the equipment.

Equipment.

76. The transport equipment of the party was as follows :—

For use on site of base line.	1	Spring Tent Wagon.
	1	Cape Cart, open.
	1	Cape Cart, with hood.
	1	Trolley.
	1	Water Cart.
	19	Mules.
	3	Horses.

For such journeys as were made by road, the necessary additional transport was obtained locally.

Cost.

77. The total cost of measuring the base lines (excluding sales) has been £10,660. The number of lines is five, and their combined length 69½ miles, so that the cost per base has been £2,132, and the cost per mile of base £153 *7s.* *8d.* The cost of reconnoitring the base line sites has been £2,025.

LEVELLING FROM MEAN SEA LEVEL.

Levelling programme.

78. It was the intention at the initiation of the Survey to carry lines of levelling from mean sea level along all the lines of railway in the Transvaal and Orange River Colony, breaking off at suitable points to connect with the base lines. Lourenço Marques being the nearest port to the Transvaal, and necessitating a minimum of work in territory not concerned with the Survey, was clearly the datum from which to start. The original programme of work was, therefore, drawn up as follows :—

		Length in miles.
Section 1.	Lourenço Marques, through *Belfast* to Pretoria ...	349
„ 2.	Pretoria through Germiston to Potchefstroom ...	134
„ 3.	Potchefstroom, by road through Ventersdorp and Lichtenburg, to *Ottoshoop*...	110
„ 4.	Germiston to *Kroonstad*	126
„ 5.	Kroonstad to Bloemfontein	128
„ 6.	Bloemfontein, by road, to *Wepener*...	75
„ 7.	Pretoria to Pietersburg, and by road to *Houts River*	198
	Total	1,120

The Base lines are in italics.

Exceptions.

79. If time and the necessary funds had been available, the intention was to have continued the levelling along the remainder of the railway lines in the two Colonies. But it was very early seen that the full programme had no chance of being completed, however advantageous such a backbone of accurate levelling would have been for many of the requirements of a comparatively new and developing country.

Work actually done.

80. The ultimate programme decided upon included only Sections 1, 2, and 4 above, representing 611 miles of levelling. In coming to this decision, it was not forgotten that, as only two base lines (Belfast and Kroonstad) were directly connected with the mean sea level, the heights above mean sea level of the others were entirely dependent on the results of the vertical angles, and that the probable errors of these heights compared to the radius of the earth should not exceed the probable error of the measurement of the base lines; or, in other words and assuming that the probable error of a measurement is one millionth of the length, that the probable error of a vertical height should not exceed 21 feet. It is shown in the discussion of the vertical angles that the probable error of these heights does not in any case exceed 10 feet (*see* paragraph 81). Advantage was taken of the stations at Observatory Hill and Muckleneuk being comparatively close to levelling bench marks to connect them by levelling with the latter.

Comparisons.

81. Probable error of heights of base lines above mean sea level through the vertical angles:

Wepener Base,	through	830	miles of chain	10 feet.
Ottoshoop	„	520	„ „	8 „
Houts R.	„	440	„ „	7½ „

A comparison between vertical angle heights and those obtained by levelling gives:

	Levelling.	Vert. ang.	L – V.
Belfast Base	6399·9	6391·4	+ 8·5 feet.
Observatory Hill ...	5936·1	5930·0	+ 6·1 „
Kroonstad Base ...	4684·4	4691·7	– 7·3 „
Muckleneuk	4748·6	4739·8	+ 8·8 „

Instruments.

82. The levelling instrument, levelling staves, and the standard bar measure with which to compare the levelling staves, were all obtained from Messrs. Ponthus and Therrode, 6, Rue Victor-Considérant, Paris. They are all fully described in a book entitled "Nivellement de Haute Précision," by Charles Lallemand, and published in Paris by Baudry & Co., 15, Rue de Saints-Pères. It is not considered necessary to describe them in detail here, but the photographs, Nos. 7, 8, 15, and 25, are fair representations of all.

Mr. Lowinger's report.

83. The history of the work, general description of the instruments, detail of work in the field, method of reducing the observations, etc., with a list of the bench marks fixed, are given in Mr. Lowinger's report, which is carefully and concisely prepared.

Bench marks.

84. The bench marks have all been specially inspected by Mr. P. C. Morgenrood, and handed over for safe guarding to a representative of the

Central South African Railways Administration, who accompanied Mr. Morgenrood and visited each one.

Summarised, they are located as follows :—

Lourenço Marques to Pretoria ...	Nos. 0 to 24, and 01 to 024
On Pretoria Govt. Buildings ...	„ 25
Pretoria to Germiston	„ 26 to 31
Germiston to Potchefstroom ...	„ 32 to 47
Germiston to Kroonstad ...	„ 48 to 62

The inspection resulted as follows :—

A. Only four of the caps were missing, namely: one on the Delagoa Bay line, two on the line to Potchefstroom, and one on the Kroonstad section. These have all been replaced.

B. The following bench marks are for the moment unserviceable :—

No. 0 (on power house at Lourenço Marques) is broken off close to the flat iron portion in the wall. The bracket, with the brass fitting, was not to be found.

No. 36 The culvert in which this bench mark had been fixed has since been covered over, but it is accessible, and the Central South African Railways administration will see that it is correctly transferred to another point.

No 37 is now buried under the Zeerust line, but this bench mark will also be transferred as above.

No. 33, originally on the old "Pretoria bridge," Johannesburg, has been transferred to the lavatory wall, Park Station. The height above mean sea level of the new bench mark is the same as that of the old (5,700·0 ft.).

C. Owing to the shortening of railway lines wherever possible, the mile posts are altered to correspond, and this must be taken into account when they are referred to as guides.

D. The levelling was started at Lourenço Marques, from the port captain's datum, which is 6·124 M. above mean sea level, at a spot marked on a concrete block near the old yacht club boat house, behind the port captain's offices.

Standardising apparatus.

85. Paragraph 7 of Mr. Lowinger's report describes the standardising apparatus. Photographs Nos. 26 and 27 show the two ends of the rod. The value of a division on the steel rod at the free end is obtained as follows :— Its value is such that it shall be equal to the relative expansion of the steel rod with reference to the brass when the latter undergoes an absolute lengthening of 10 centi-millimetres per metre. * The increase corresponding to a temperature t for the brass is

$$\beta t = 0{\cdot}0001 \text{ mm.}$$

The relative expansion of the brass and steel is

$$v = (\beta - \alpha) \, . \, t\mathrm{L},$$

where

α = coefficient of expansion of steel,

β = „ „ brass,

L = length of the rods (3·2 M.),

v = the value of a division;

whence

$$v = \frac{\beta - \alpha}{\beta} \cdot \frac{\mathrm{L}}{10{,}000} \text{ mm.},$$

or

$$v = 12{\cdot}6 \text{ c/mm., assuming} \begin{cases} \alpha = 0{\cdot}0000115, \\ \beta = 0{\cdot}0000190. \end{cases}$$

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* Extract from M. Lallemand's book referred to in para. 82.

The 40 divisions on the scale are, therefore, 504 c/mm. in length. There is no vernier for reading the fractions of a division, which are estimated by the eye with the aid of a magnifying glass.

Use.

86. Photo No. 14 is a reproduction, on a larger scale, of a table supplied with the instrument, which serves to give the correction to be applied for temperature, per metre. In comparing the faces of the levelling staves with the standard, they are separately laid on a level bench, face upwards, and on them is placed the standardising rod with its face vertical, and the two are clamped together by means of steel stirrup irons and wooden wedges. At the end of the standard, where the brass and steel rods are fixed to each other, is a micrometer, which actuates the movement of the two rods as a whole, and reads to centi-millimetres by inspection. The special microscope for reading the comparisons is of the "Coudé" form (photo No. 28). The rays of light come from the object at an angle of 53° to the vertical, and then passing through the lens prism reach the eye at an angle of 45°.

Comparisons of staves.

87. In making the comparisons, readings between the brass-divided rod and the scale divisions on the staff were made: for Faces I, at 0, 20, and 30 decimetres; and for Faces II, at 32, 41, and 54·5 decimetres. The record of the observations and the resulting corrections per metre would read as follows:—

STAFF 4.

FACE I.

	Difference.	Correction.	Sum.	
mm.	mm.	mm.	mm.	
Zero 2·582 10 dm. 2·885	+0·303	+0·390	+0·693	Reading of metallic thermometer, 216
Zero 2·557 20 dm. 2·998	+0·441	+0·780	+1·221	
Zero 2·584 30 dm. 3·008	+0·424	+1·170	+1·594	
			6) 3·508	
		Correction per metre	+0·585	

The divisor = 1 + 2 + 3.

FACE II.

	Difference.	Correction.	Sum.	
mm.	mm.	mm.	mm.	
32 div. 3·533 41 ,, 3·749	+0·216	+0·390	+0·606	Reading of metallic thermometer, 216
32 ,, 3·574 50 ,, 3·729	+0·155	+0·780	+0·935	
32 ,, 3·542 54·5 ,, 3·655	+0·113	+0·975	+1·088	
			6·05) 2·629	
		Correction per metre	+0·435	

The divisor = $\frac{11}{90}$ (9 + 18 + 22·5).

The corrections were always applied directly to the respective face readings, those on Face II being first reduced to the metrical scale by multiplying by $\frac{11}{9}$.

Standardising apparatus necessary in the field.

88. There is no doubt that, for the highest accuracy in this levelling, the standardising apparatus should have been demanded in duplicate from Europe, and that one set should have accompanied the levelling party in the field for more frequent and systematic comparisons with the levelling staves. With only one such apparatus available, it would not have been advisable to risk injury to it during transit along the veld, and the comparisons were all made at Pretoria.

Results of comparisons.

89. The results of the comparisons of the levelling staves with the standard are given in paragraph 8 of Mr. Lowinger's report. A very complete set of comparisons were forwarded from Europe with the levelling apparatus, but these could not, of course, be utilised out here. It is interesting, however, that the corrections per metre for the staves as found in Paris very closely agree with the mean of the whole range of comparisons made out here.

Paris comparison.			Local comparison.	
	mm.	Staves 1 and 2.	mm.	
+ 0·40	+ 0·51	Mean of Faces I	+ 0·45	+ 0·37
	+ 0·29	,, ,, II	+ 0·28	
		Staves 3 and 4.		
+ 0·43	+ 0·50	Mean of Faces I	+ 0·51	+ 0·40
	+ 0·36	,, ,, II	+ 0·29	

Limitations and table of results.

90. There has been neither time nor funds for carrying out the levelling in any sense "geodetically," or with any greater precision than could be obtained by the use of the special levelling staves and instrument and measurement in one direction only. There is, therefore, no strict method of arriving at the probable accuracy of the work. One idea of the accuracy is given by a comparison of the results from Faces I and II, and this is embodied in the following table showing the general work and results of the levelling :—

TABLE SHOWING GENERAL RESULTS OF LEVELLING.

	a.	*b.*	*c.*	*d.*	*e.*	*j.*	*g.*	*h.*	*k.*	*l.*
Location of section.	Length of section.	Diff. of level of extremities.	Range of diff. of level.	Diff. of Faces, II–I.	Diff. of Faces without regard to sign.	Sum of squares of the individual differences, II–I.	Probable error of levelling the section.	Probable error of levelling one mile of section.	Probable error per 100 metres of diff. of level.	C. $\sqrt{\text{miles}}$.
	miles.	metres.	metres.	mm.	mm.		mm.	mm.	mm.	C./mm.
M.S.L. at Delagoa Bay to 134th mile..	134	+674	719	—56·2	—65·6	1892·6	20·5	2·32	11·7	1·77
134th mile to 238th mile	104	+929	1556	+ 8·4	—21·2	2354·4	22·9	0·40	2·6	2·25
238th mile to 336th mile	98	−301	895	+75·7	—30·5	1616·4	18·9	3·65	4·9	1·91
336th mile through Pretoria to Klip River	77	+151	641	—15·0	—42·6	432·2	9·8	0·53	8·0	1·12
Klip River to Kroonstad	105	— 56	386	+39·1	+15·9	562·7	11·2	0·52	3·9	1·09
Johannesburg to Potchefstroom ..	93	—312	568	— 1·7	—12·9	221·0	7·0	0·35	2·6	0·73
Totals, etc.	611	+1085	4765	+50·3	—156·9	7079·3	40·1	0·99	10·8	1·62

As might have been expected the later half of the work shows better results than the earlier.

The quantities in columns g, h, and k have been obtained as follows :—

$$g = q \cdot \sqrt{\frac{f}{2}}\,; \quad h = q \cdot \frac{d}{\sqrt{2a}}\,; \quad k = q \cdot \frac{e}{\sqrt{\frac{c}{50}}}$$

where $q = 0{\cdot}6745$.

The constant in column $l = \frac{g}{\sqrt{a}}$.

Equipment.

91. The equipment of the levelling party was as follows :-

Transport
- 1 tent wagon, from base line party.
- 1 Cape cart, open.
- 8 mules.
- 4 horses.

Instruments
- 2 levelling instruments (one only at a time in the field.
- 4 levelling staves (two only at a time in the field).

Cost.

92. The total cost of the levelling amounted to £3,424, or at the rate of £5 12*s.* 1*d.* per mile. A total of 87 bench marks were fixed, at an average distance apart of about 7 miles.

DESCRIPTIVE LIST OF TRIGONOMETRICAL POINTS.

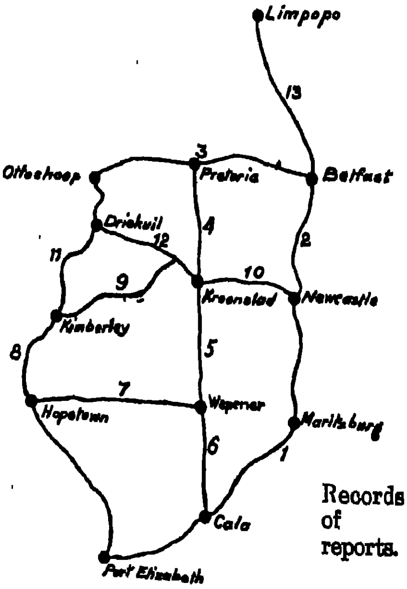
Descriptive heads.

93. With a view to indicate as clearly as possible the parts of the Transvaal and Orange River Colony in which the various trigonometrical stations are located, the necessary information is presented in tabular form. For each station the information is arranged as follows :—

Column 1. Name of station.
„ 2. Reference number in the computation results.
„ 3. Farm on which it is situated.
„ 4. Name of owner or occupier.
„ 5. District.
„ 6. Nearest magistracy, post office and telegraph office.
„ 7. Remarks on site of station.

Grouping of stations.

94. For convenience of reference the stations are divided into groups, as follows :—



—		No. of Chain.	No. of Stations.
Group	I. Kimberley to Ottoshoop ..	11	50
„	II. Driekuil to Kroonstad	12	8
„	III. Newcastle to Belfast	2	28
„	IV. Belfast to Limpopo	13	16
„	V. Belfast to Ottoshoop	3	15
„	VI. Pretoria to Cape Colony. ..	4, 5 & 6	37
„	VII. Kimberley to Newcastle ..	9 & 10	19
„	VIII. Hopetown to Wepener	7	12

The diagram in margin shows the numbering of the chains.

Records of reports.

95. The descriptive list has been compiled as carefully as possible from the reports sent in by the reconnaissance, beaconing and observing officers, which have been classified and docketted for record by Mr. S. B. Morgenrood. The classification of these, as well as of all reports on the

roads traversed by the various parties, appears in that gentleman's report. His work has been admirably done.

96. However useful the above reports have proved, they are not of sufficient importance to include in this report; but the records will always be available for any future reference that may be necessary. Records kept but not printed.

BAR COMPARISONS.

97. The bar apparatus, which was used by the base line party for laying down the ground standards, consisting of five 10-ft. steel bars, is the same as was employed in the measurement of the base lines on the Cape-Natal Survey, 1883–93. The lengths of these bars and their coefficients of expansion, as determined during that survey, have been utilised without alteration in the present work. But as the comparisons with the Cape Standard Bar A had been made 15 years ago, and the bars had had a good deal of knocking about since then, it was deemed advisable to repeat these comparisons, using the comparison apparatus as on the previous occasion of 1888. Bar apparatus.

98. A wood and iron hut was erected in the yard of the Survey Office, and the comparison apparatus set up and arranged as was done at the Cape. Photograph No. 21 shows the apparatus in position in the hut. The first set of comparisons was made during September and October, 1905, and the second set in July and August, 1906. A full discussion, and the results, of these comparisons appears in Mr. Robinson's report. The results of the 1906 comparisons, made under more favourable conditions than those of 1905, show that there has been no appreciable change either in the lengths of the bars or in their coefficients of expansion. The comparisons of 1905 were made by Messrs. Robinson and Cochrane; those of 1906 by the Superintendent and Mr. Robinson. Bar comparison apparatus.

99. A very serious defect was discovered during the bar comparisons. It was found that the fine terminal lines drawn on the piece of gold let into the standard bar could not be brought into parallelism with the lines on the compared bars, necessitating that the observations of the lines on the standard should always be made in the neutral axis marked by the original dots in the gold, or in other words, that whereas the lines on the five compared bars were all parallel to one another, as each was brought under the terminal micrometers, the lines on the standard, when similarly treated, were permanently out of parallel, and there was no means of adjusting this. There is no doubt that the lines on either the standard bar or the compared bars are not at right angles to the neutral axis, and the extent of this want of parallelism is the equivalent of nearly two inches in ten feet. This divergence is altogether beyond the field of view of the micrometers, so that no mechanical arrangements could rectify it. Defect in bars.

The steps taken to test this want of parallelism are fully described in Mr. Robinson's Report. But there are no satisfactory means of determining which of the bars have this defect, except that it was found that, when the micrometers were adjusted in the first instance in accordance with the method indicated in the report on the Cape–Natal Survey, 1883–93, the lines on the compared bars were parallel to the movable wires in the micrometers, whereas this was not the case with the lines on the standard bar; showing that the latter is probably defective.

ASTRONOMICAL OBSERVATIONS.

100. The astronomical observations have been limited to the determination of latitude and azimuth. Observations for azimuth were limited to base lines, at one or other terminal, and junctions of triangulation chains. They are as follows:— Astronomical stations. Azimuth.

Base lines	Houts River,	South	terminal.
	D. Ottoshoop,	North	„
	D. Belfast,	South	„
	D. Wepener	North	„

Junctions of chains
D. Observatory Hill, Johannesburg.
Driekuil.
D. Boschrand (also near Kroonstad base)
Orange River Station (Cape Colony).
D. Cweeweni.

In other colonies.

101. In addition to the foregoing, there are available the results of observations previously made during the Cape–Natal Survey at—

Newcastle (Natal).
Zwaatkop „
Umtata (Cape Colony).
Kimberley „
Berlin „

Latitude stations.

102. All the foregoing are also latitude stations, but as observations for latitude are much simpler and of more importance than those for azimuth, they were taken at 26 additional points in the Transvaal and Orange River Colony, making a total of 35 in the new Colonies. The 26 points are given below :—

Lejuma.
Blaauwberg.
Loskop.
Houts River, N. end.
Schnellskop.
D. Belfast, N. end.
D. Mare's Kop.
D. Langekloof.
Meintjes Kop.
Muckleneuk.
D. Gemsbokberg.
D. Inkwelo.
D. Kaalkop.
D. Vierfontein.
D. Hermitage.
Zoetvlei.
Braunzijnkop.
Salt Lake.
Theron's Kop.
Schoongezicht.
D. Wepener, S. end.
D. Aasvogelberg.
D. Helvellyn.
D. Bendearg.
D. Xuka.
D. Lubisi.

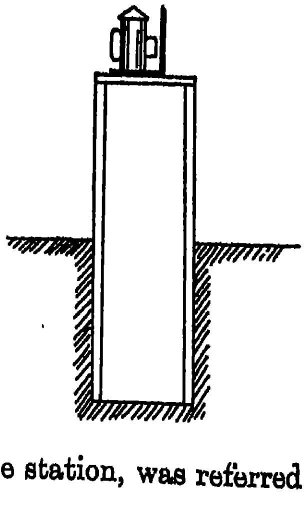
AZIMUTH OBSERVATIONS.

Observing for azimuth.

103. Azimuth was always determined by the combination of the upper and lower culminations of circumpolar stars, and the observations taken with the 10-inch Repsold theodolite, either mounted on its portable tripod or on a concrete pillar, and protected by its portable hut.

Meridian mark.

104. A reference mark was erected as near to the meridian of the station as was convenient for observing, illuminated at night by a bull's eye lantern shining through a circular aperture in an iron plate attached to a pillar fixed in the ground. The most convenient form of pillar is a wooden box five feet long and one foot square in section, sunk from two to three feet in the ground, and filled with earth well rammed. The arrangement is shown in the sketch. If, on completion of the observations, others are to follow, the box and iron plate may easily be removed and taken to another station.



Azimuth of mark.

105. The astronomical observations determined the true bearing of the mark with reference to the south point, and to it one point, at least, visible from the station, was referred by horizontal angle measurement.

106. The record of the astronomical observations was made in a field book, as shown below:—

Field book record.

Circle West.

Star 1803.					Star 452 (S.P.)				
Micrometer on Mark.	Level.		Micrometer.	Transits.	Micrometer.	Transits.	Level.		Micrometer on Mark.
	W.	E.					W.	E.	
rev.	div.	div.	rev.	h. m. s.	rev.	h. m. s.	div.	div.	rev.
5·068	50·5	17·4	6·390	15 22 48·2	8·810	15 31 19·8	10·5	43·6	5·064
·061	14·1	47·2	·579	59·0	·334	34·1	51·0	17·9	·075
·069			·805	23 11·8	·020	43·6			·080
·055			·999	24·7	7·378	32 4·0			·065
·074			7·378	46·8	6·979	15·4			·068
			·609	24 0·0	·540	29·3			
Reading of the Collimation centre. 5·132			·821	12·5	·145	41·2	Value of Revolution of Micrometer 90″·22		
			8·049	26·0	5·480	33 1·8			
			·245	37·2	·145	12·3			
			·481	48·2	4·784	22·6			

107. The above observations were reduced as follows:—

Reduction.

CIRCLE WEST.

Star 1803 (U).

1.	2.	3.	4.	5.	6.
rev. 5·132	—	1·7711		m. s.	h. m. 15·21
6·390	1·258	0·0997	1·8708	1 14·27	33·98
·579	1·447	·1605	·9316	25·43	33·57
·805	1·673	·2285	1·9946	38·77	33·03
·999	1·867	·2711	2·0422	50·20	34·50
7·378	2·246	·3514	·1225	2 12·59	34·21
·609	2·477	·3939	·1650	26·22	33·78
·821	2·689	·4296	·2007	38·74	33·76
8·049	2·917	·4649	·2360	52·19	33·81
·245	3·118	·4932	·2643	3 3·78	33·42
·431	3·299	·5184	2·2895	14·76	33·44
74·306	22·986		Mean of Transits	23 49·44	33·74
		0·36146	2·13256	− 2 15·70	
7·4306	2·2986				

Check diff. 5·132

15 21 33·74
Aberration — ·19
Level 4·82

Transit over C.C. 15 21 38·37 .. *t*
Right ascension 15 21 38·58 .. *a*

a — *t* + 0·21 .. U

Reading of Mark 5·067
" " C.C. 5·132

M — C — 0·065

Log 8·8129
Log Rev. Micrometer 1·9553

0·7682 .. — 5·86

Star 452 (L).

1.	2.	3.	4.	5.	6.
rev. 5·132	+	1·4859		m. s.	h. m. 15·33
8·810	3·678	0·5657	2·0516	1 52·62	12·42
·334	3·202	·5054	1·9913	38·02	12·12
·020	2·888	·4606	·9465	23·41	12·01
7·378	2·246	·3514	·8373	8·76	12·76
6·979	1·847	·2664	·7523	0 56·53	11·93
·540	1·408	·1485	·6344	45·09	12·39
·145	1·013	·0055	·4914	31·00	12·20
5·480	0·348	9·5416	1·0275	10·65	12·45
·145	+ 0·013	8·1139	9·5998	0·40	12·70
4·784	— 0·348	9·5416	1·0275	10·65	11·95
67·615	16·295		Mean of Transits	32 22·41	12·29
	1·6295	0·2121	1·6980	+ 0 49·88	

15 33 12·29
Aberration + ·10
Level — ·27

Transit over C.C. 15 33 12·12 .. *t*
Right ascension 3 33 18·15 .. *a*

a — *t* +6·03 .. L

L — U + 5·82

Log 0·7649
Log Σ (Azimuth factor) 9·9538

0·8111

Azimuth of Instrument + 6·47
∠ Mark and Instrument — 5·86

Azimuth of Mark $\boxed{+ 0\cdot61}$

Or Azimuth of Mark is 0° 0′ 0″·61 measured from the South Westwards.

In Col. 1 are entered the successive readings of the movable or fixed wires.

„ 2 the differences between each of the above and the reading of the collimation centre.

„ 3 the logarithms of these differences.

„ 4 the logarithms added to the log. given at top of col. 3 of the collimation factor of the star multiplied by value of micrometer revolution.

„ 5 the values in time to be applied to corresponding times of transit.

„ 6 the transit times on collimation centre.

It is to be noted that :—

A. All transits are reduced to the coll. centre.

B. The means of cols. 1 and 2 should add together, algebraically, to the reading of the coll. centre, as a check.

C. In col. 5 the correction applied to the mean of the recorded transits should agree with the mean of the reduced transits in col. 6.

D. The sign of the azimuth of the instrument is always obtained by first taking $\alpha - t$ for both stars, and $L - U$, L being the lower, and U the upper culmination star.

E. The sign of the correction to the instrumental azimuth to obtain azimuth of mark is—

	Circle West.	Circle East.
Meridian Mark to South	M — C	C — M
„ „ North	C — M	M — C

where

M represents the reading of Mark,
C „ „ Coll. centre.

108. The results of the observations for azimuth are given in Table T for each of the nine stations separately, under headings :— **Final azimuth results.**

Right ascensions of stars.
Transits.
Readings of mark and level.
Resulting azimuths of mark.

The readings of the mark are in revolutions of the micrometer. Those of the level are in divisions of the level for Belfast, Ottoshoop, Observatory Hill, Driekuil, Boschrand, and Orange River; in seconds of arc for Houts River, Wepener, and Cwecweni. This is due to the difference of method adopted by the two observers in taking the readings. For the first mentioned set of points, the level was read just before the transit of the first of a pair of stars and reversed, and again read after the transit. For the remainder a full reading was taken before transit of the first of a pair, and after the transit of the second. If any change occurred between the two readings, the values at the star transits were interpolated.

109. Another important difference of method between the two observers was that, for the first-mentioned stations, the face of the instrument was systematically changed to allow of a combination between the results, circle west and circle east, as an integral observation. For the others, as it will be noticed, observations were taken continuously on one face and then continuously on the other. **Methods of observing.**

110. It is to be observed that the form in which the observations at each station are presented (*see* table T) permit of their reduction at any future time. There was neither time nor computers available for two independent reductions **Reduction of observations.**

to be made as a check upon each other, as has been done in the case of all other final results of the survey. But every possible check that a single computer could bring to bear on the work has been applied throughout, and no clerical or other errors could have occurred that would appreciably affect the results.

Observers' share of work.

111. The astronomical observations were made by three observers, namely: Captain Gordon, Mr. Simms, and the Superintendent, as shown below:—

	Latitude stations.	Azimuth stations.
Capt. Gordon	Meintjeskop. Muckleneuk. Gemsbokberg. Inkwelo. Kaalkop. Vierfontein. Hermitage. Zoetvlei. Braunzijnkop. Salt Lake. Theron's Kop. Schoongezicht.	nil.
Mr. Simms.	Lejuma. Blaauwberg. Loskop. Houts R., N. end. Schnellskop. Houts R., S. end. Wepener, N. end. Wepener, S. end. Aasvogelberg. Helvellyn. Bendearg. Xuka. Lubisi. Cwecweni.	Houts R., S. end. Wepener, N. end. Cwecweni.
Superintendent	Belfast, N. end. Mareskop. Langekloof. Ottoshoop. Belfast, S. end. Observatory Hill. Driekuil. Boschrand. Orange River.	Ottoshoop, N. end. Belfast, S. end. Observatory Hill. Driekuil. Boschrand. Orange River.

Captain Gordon and Mr. Simms observed as opportunities offered during the course of their field work on the triangulation chains.

Chronology of astronomical party.

112. The Superintendent's party observed between—

1904. January 24th and April 12th at	Belfast, S. end. Belfast, N. „ Mareskop. Langekloof.
April 13th and July 8th at	Observatory Hill. Ottoshoop.
1905. August 15th and October 28th at	Boschrand. Orange River. Driekuil.

The periods include the time occupied in movements from one station to another.

113. The party was equipped as follows :— **Equipment.**

Transport	1 Buggy (to carry theodolite and chronometers). 1 Cape cart, with hood. 2 Cape carts, open. 16 Mules. 3 Horses.
Instruments	1 Repsold theodolite and stand. 1 Portable observing hut. 2 Chronometers. 2 5-inch Heliographs. 1 Telescope and stand.

LATITUDE OBSERVATIONS.

Latitude. 114. The Latitude observations were all taken with the Repsold theodolite used as a zenith telescope (Talcott's method). A very full account of the method is given in Chauvenet's "Spherical and Practical Astronomy," Vol. II, chap. VIII.

Stations and distribution. 115. Table U gives the results of the observations of 35 stations, distributed as follows :—

Transvaal	15
Orange River Colony	12
Natal	2
Cape Colony	6

The two stations in Natal are at the junctions of chains in the neighbourhood of Newcastle. Of the six stations in Cape Colony, two are at the junctions of chains, and four are stations in the meridional chain between Pretoria and Cala.

Stations in other Colonies. 116. In addition to the above, there are available for the general reduction those made on the previous Survey of the Cape Colony and Natal at

Newcastle, Natal.
Zwartkop, Natal.
Kimberley, Cape Colony.
Umtata, Cape Colony.

Star places. 117. Definitive star places have been obtained for 20 out of the 35 stations, and the results at these 20 stations may be considered as final. They are marked D in paragraphs 100 and 102.

For the remainder the places depend on the following catalogues, in which most of them are found, with their reference letters :—

Cape Catalogue, 1880	S
Radcliffe Catalogue, 1890	R
Cape Catalogue, 1890	C
Greenwich Catalogue, 1890	G
Newcomb's Fundamental Catalogue	N
List of stars specially observed at the Cape Observatory ...	⊙
Cape General Catalogue, 1900	CGC
Cape Astrographic Catalogue, 1900	A

The several catalogues in which a star appears have been noted by these letters placed against them. It is to be noted, however, that catalogues CGC and A were only received after the whole work of reduction had been completed, and too late, therefore, for the places of the stars appearing in them to be utilised. But it is the intention to utilise them, as well as those of a large number remaining to be specially observed at the Cape, when the latter are supplied.

Special remarks on latitude table.

118. The general results of the observations are given in the first table, which speaks for itself, but a note is necessary as regards the column headed $\frac{\Sigma Z_n - \Sigma Z_s}{\text{number of pairs}}$. One of the conditions necessary to be considered in the selection of pairs of stars for a station is that "the greater zenith distance should be as often that of the northern as that of the southern star, as an error in the value of the micrometer screw will thereby be rendered less sensible. In general, for any number of pairs the effect of such an error upon the final result will be the more nearly insensible the more nearly we approach the condition $\Sigma Z_n - \Sigma Z_s = 0$," where ΣZ_n is the sum of the greater northern distances, and ΣZ_s is the sum of the greater southern distances. The column above referred to serves to show how nearly this condition was fulfilled at each station, as well as the extent to which the resulting latitude would be affected by an error in the adopted value of the micrometer screw. For instance, at Aasvogelberg, where the quantity is large, an error in the revolution of micrometer of a thousandth part would alter the latitude by 0″·17.

Corrections.

119. In the tables of individual results at a station, the column headed "Sum of Corrections" includes the corrections for

The apparent place of the stars,
Micrometer,
Level,
Refraction.
Reduction to Meridian,
Variation of gravity,

which are proper to the date of observation, the instrument, and locality. Assuming that these corrections are exactly determined and applied, the exactness of the resulting latitude is dependent on the mean places of the stars and the extent to which the plumbline deviates from the true normal to the surface at a station.

Comparisons.

120. There is no question that the latitude is better determined at the 20 stations referred to in paragraph 117. A comparison between these results and those for the remainder show that for the—

$$\text{former}\begin{cases}\text{the p.e. of a single declination is } 0''{\cdot}40,\\ \text{the p.e. of the resulting latitude is } 0''{\cdot}13,\end{cases}$$

and for the

$$\text{latter}\begin{cases}\text{the p.e. of a single declination is } 0''{\cdot}62,\\ \text{the p.e. of the resulting latitude is } 0''{\cdot}16.\end{cases}$$

The mean p.e. of the result from a single pair of stars throughout the observations is 0″·33.

Initial latitude point.

121. It would appear from the results A-G, given in the Table, that the initial latitude (Buffelsfontein, Cape Colony) for the geodetic computations is numerically too large by nearly 3″. There also appear to be pronounced abnormal deviations of the plumbline in the neighbourhood of Newcastle in Natal, Cala in Cape Colony, Johannesburg, and the Northern Transvaal. Excluding the stations in these parts, the mean A-G for the remainder is − 2″·91.

Illumination of field.

122. When observing astronomically, the field of view of the instrument was illuminated by means of bull's-eye lanterns resting on wooden supports attached to the sides of the hut, east and west, thereby replacing the small axis lamps supplied with the instrument. In this way the illumination was constant and steady, and the heating of the bearings of the theodolite was obviated. The axis-lamp, being close to the instrument, never behaved satisfactorily in high winds with the gusts blowing in at the opening in the roof, the light then flickered a good deal, and was very often blown out.

Footplates.

123. The circular brass footplates were always steadied on a concrete pillar by bedding lightly on a thin slab of neat cement, and it is suggested

that they should be similarly treated when resting on the portable wooden stand at points where concrete pillars are not erected.

Stability of Theodolite Support.

124. In observing with so perfect an instrument as the Repsold theodolite, it is essential to ensure the stability of the base on which it rests. The best work has been done when it rested on a pillar of concrete built up on a foundation of bed rock. Confidence in the results of the observations is weakened when the instrument is directly borne on a wooden stand, however well seasoned the wood may be, which is liable to creeping movements due to changes of temperature and moisture. It is absolutely necessary to test by the body weight whether the ground is firm or not, and this is best shown by the level of the instrument when mounted.

SIGNALLING INSTRUCTIONS.

Instructions to Signallers.

125. With a view to ensure some uniformity in the use of the heliograph, the general description and the method of setting up of which is detailed in the report on the Cape-Natal Survey, the following instructions were issued :—

A. On arriving at a station, the signaller should first make sure of the verticality of the beacon pole, re-adjusting the wire guys and stone pile, if necessary.

B. The helio is then to be placed in such a position that the mirror which transmits the light to the observing station is in the exact alignment between the beacon pole and the observer.

C. The approximate compass bearings of the distant points as well as of other points visible are given in the description of the trigonometrical stations made by the reconnaissance and beaconing parties.

D. The light should be shown to the observing station both morning and evening from sunrise onwards till the call " C W N " is received, and from a pre-arranged time in the afternoon till sunset. At those times the light should be turned on without waiting for any preliminary call from the observing station.

E. On the completion of the observations at the distant point, the word "finished" will be sent to the signaller. On the receipt of this word the signaller is to make the next move assigned to him in the "General Scheme of movements." He must, on no account, abandon his station until this word, at least, is received.

F. The signaller should be in constant attendance on the heliograph and maintain the light in proper adjustment. If a steady light is shown at the distant station, it indicates that the signaller's light is not good. The observer will drop his light directly he is satisfied with the light he sees.

G. The signaller should use every endeavour to make the beacon and its discs clearly visible to the observer by removing obstacles such as bush, long grass, or stones both before and behind the beacon, in the latter case that the beacon may be projected on the sky where possible. In cloudy weather he should be careful to remove his helio and stand clear of the beacon.

H. In order to test the accuracy with which the light is directed to the distant point, as well as make sure that, during signalling, the flashes are received with clearness, frequent practice should be made of directing the light on some convenient mark near at hand, so that the whole spread of light may be seen. This should fall centrally on the mark both when the light is at rest (as it would be when showing light for observing) and also while signalling.

J. In sending messages, the dot should be made as short as possible consistent with complete exposure and obscuration of the light. The dash should be at least three times the length of the dot. The intervals between elements of a letter should be equal to one dot; those between the letters in a word equal to one dash.

K. The signaller should be careful to remember, in aligning the light, that that mirror should be placed in the alignment which *transmits* the light to the observing station. With the sun *between* the station and the distant point, this is the "direct" mirror; with the sun *behind* the signaller, the "duplex" mirror.

L. To facilitate the sending and receiving of messages, a number of abbreviations have been drawn up for use, such as the following :- -

G ..	.. Go on.
M Q ..	.. Wait.
S L ..	.. Show light.
L B ..	.. Light bad.
L C A ..	.. Is your light correctly aligned ?
T M W ..	.. To-morrow.
Y D Y ..	.. Yesterday.
B C N ..	.. Beacon.
N N ..	.. That is all, no more.
C W N ..	.. Cease work till ——.
	&c., &c.

CARE OF CAMP EQUIPMENT.

Instructions.

126. Camp equipment is subject to considerable wear and tear in the field, and its serviceable period greatly depends on the care with which it is treated. Instructions were therefore issued to all parties, as given below, for its proper handling in the field.

Flexible wire rope.

127. One novel feature was adopted with regard to tents supplied for use. Usually all the guy and tent ropes are of hemp, and contract and expand with the wet and dry experienced in the field, necessitating constant attention to keep them at the requisite degree of tautness. In order to minimise this labour, the hemp ropes were entirely replaced by ropes of flexible wire, thus leaving the canvas only of the tent to contract and expand with changes in the weather. The change proved of great advantage both in this respect as well as in the greater endurance and strength of the wire.

Instructions detailed.

128. *Instructions.*

A. The *tents* supplied to all the mobile parties in the field are double and single patrol tents; double for Europeans, single for natives. The single patrol is really the inner portion of the double patrol. The base line party is provided with double and single bell tents in a similar way.

B. All tents are liable to decay from being wet and dry; but the effect of this change, from one condition to another, is minimised by taking care that they are never packed up wet for travelling, and that attention is paid to tightening them, when standing, as they pass from wet to dry, and slackening them from dry to wet. This attention is as necessary in heavy dews as when rain is falling. A simple way of providing for this is to support the poles on pieces of wood, or even stones, which can be removed as the canvas contracts, and replaced as the tent dries.

C. All tents are supplied with *iron tent pegs*, and to each camp or party hand hammers are issued for driving them. Every care should be taken that they are not lost; their number should be counted at each move, and they should always be carried, on trek, in boxes provided for the purpose.

D. The *cooking utensils* should be used with care, and packed away in the boxes provided for their transport on trek.

E. Similar care should be taken of the candle lanterns. *No naked lights* are permitted, under any circumstances, in the tents. The natives are not to have lights in their tents, naked or otherwise.

F. *Camp* should always be pitched on high ground, and never near the banks of rivers or any standing water. It is as well to keep away from near proximity to dense bush. This applies with particular force during the summer months (October to May), when malaria and horse sickness prevail, especially in the bushveld and low country of the Transvaal.

G. Great care should be exercised during the *grass firing* season (April to September) to protect the camp. It is always desirable, when the grass is dry, to burn a ring round it, about 30 yards broad, taking care, however, that it is always done by the natives under proper supervision, so that the general veld is not set fire to.

H. The *Ordinance*, under which survey parties have right of access to lands, is attached.

TRANSPORT ANIMALS AND VEHICLES.

129. The nature of the transport supplied to the various parties in the field has been detailed in the references made to them in another part of the report. The equipment in vehicles followed generally on the lines of that which was used on the Cape-Natal Survey, the two principal items being the two-wheeled Cape cart with hood, and the so-called Scotch cart on springs. A special tent-wagon was provided for transporting the bar apparatus for road travelling, and, on completion of the base lines, it passed on to the levelling party. Equipment.

130. The mules were nearly all purchased from the Repatriation Department, which very kindly paraded all the mules they had for sale in the camp, from which the numbers required from time to time were selected, at a cost of £30 each. This would appear to be a high figure, but it is thought that, having regard to possibilities in any other market, and that selection was always made from 600 to 700 animals, the price was not altogether unreasonable. A total of 133 mules was purchased from the department. Mules.

131. The horses, 29 in number, were also purchased from the same department, at prices varying from £20 to £30. They, unfortunately, proved to be much more susceptible to horse sickness, especially the Russian ponies. Horses.

132. The following table shows the allocation of transport animals to the various parties, as well as the purchases, deaths, and final disposal on completion of the field work:— Distribution and casualties.

Name of party.	Field strength.		Actual purchases debited to each.		Died.		Sold.	
	Horses.	Mules.	Horses.	Mules.	Horses.	Mules.	Horses.	Mules.
Base Line	3	18	2	13	—	3	2	10
No. 1.—Observing party	4	42	5	36	2	5	3	31
„ 2 „ „	2	36	1	18	—	8	1	15
Superintendent (1)	3	12	3	7	—	—	3	7
„ (2)	3	18	1	9	1	1	—	8
No. 1.—Reconnaissance	3	10	3	8	—	2	3	6
„ 2 „	3	10	4	10	2	1	2	9
„ 3 „	3	10	3	12	—	1	3	9
„ 1.—Beaconing	1	5	2	6	1	3	1	3
„ 2 „	1	5	—	6	—	—	—	6
„ 3 „	1	5	—	6	—	—	—	6
„ 4 „	1	8	—	—	—	—	—	—
Reconnaissance and observations subsidiary	3	15	—	—	—	—	—	—
Beaconing, subsidiary	2	15	—	—	—	2	—	—
Levelling	4	8	3	6	2	1	1	5
Head-quarter Office	—	2	2	3	2	1	—	2
Totals	37	219	29	140	10	28	19	117

The first two columns show the total requirements if all the parties had been at work simultaneously.

It will be noticed that of the horses 33 per cent. died, of the mules only *half* that percentage.

Of the animals sold, 12 horses and 108 mules were purchased by the Public Works Department.

Cost of animals.

133. The total cost of the animals has been:—

Mules	£4,127	£4,859
Horses	732	
Their sale has realised—		
Mules	£1,937	2,184
Horses	247	
Actual cost to the survey		£2,675
Cost of dead—		
Mules	£687	
Horses	244	
	£931	

Instructions.

134. The instructions issued with regard to the transport were as follows:—

Introduction.—It is important to remember that the progress of the survey depends to a large extent on the proper care of the horses and mules, so that they are kept in a fit condition for work.

A. *Ration.*—During the summer months, while the grass is good, the daily ration should be—

6 lbs. crushed mealies. 4 lbs. oat hay.

or, if oat hay cannot be obtained, 7 lbs. crushed mealies, with sufficient chaff to prevent the animals from bolting the food.

The first feed to be given as soon as there is any light in the morning, half the above, and the remainder for the evening meal, so soon as the animals have been watered and picketted down for the night.

Throughout the day, when not on the move, they should be allowed to graze, knee-haltered or otherwise as considered safe, and under proper charge of one or more natives.

In the winter, when the grass is poor, or burnt off, the daily ration will be increased to 8 lbs. mealies, and other items correspondingly.

New mealies should be avoided, if possible; they are liable to cause diarrhœa. Oat hay should always be given after the mealies.

B. *Watering.*—Animals should be watered three times a day, and always *before* feeding. Any inordinate desire for drinking should be checked. If, as might happen in the early morning, they cannot be watered before the meal, it should be postponed to not less than two hours after, especially after a feed of mealies. Whole mealies should previously be softened in water. No horse or mule is to have a full drink unless he is quite cool.

C. *Grooming.*—Both horse and mule require thorough grooming at least once a day, and this should be done in the evening, to make the animal comfortable for the night. The heels should never be washed to clean them; mud, or moist dust, should be allowed to dry, and then brushed off. It is well, after a dusty trek, to sponge out the eyes and nostrils. The saddle should never be taken off without at once wiping over and drying the back. This is especially necessary when the animal does not have its roll on the ground when taken out from the cart or from under the saddle.

D. *Clothing.*—The clothing should always be put on at night, whatever the weather, and taken off just before trekking, or when the sun has risen, while stationary. During rain, it should always be kept on in stationary camp, and always thoroughly dried before packing for trekking, or at the first halt, if possible.

E. *Picketting.*—The animals are picketted by attaching their reims to head collar or neck band, to lengths of picketting rope which are attached to special ringed iron pegs, driven into the ground by sledge hammers provided for the purpose. The reim should have a proper length, not so long that the animal can get his hind leg caught between it and the picketting rope, nor so short as to prevent his rolling on the ground and getting up after. The proper length is got by letting the animal hold his head naturally over the picketting rope and tying the reim to that length. It is very desirable that this fastening should be undone easily in case of accident or fright and pulling back.

F. *Knee-haltering.*—Great care should be taken in knee-haltering, and while animals are knee-haltered they should be driven slowly to stables and always approached gently.

G. *Harness, saddlery, &c.*—Saddles, bridles, harness, and all leather exposed to alternations of dry and wet weather, and generally, should be carefully cleaned and kept properly pliant and in good condition by soft soap, castor oil, and dubbing as required.

H. The *Carts* should be cleaned after the day's trek and the axles well greased.

HEALTH OF PERSONNEL AND ANIMALS.

Health of men and animals.

135. It was deemed advisable to instruct those in responsible charge of parties in the field on the diseases to which men and animals are liable, and to state the remedies that should be applied. The two chief diseases with which they might come into contact were considered to be malaria for the men and horse sickness for the animals. In order to minimise, however, the risk of either, the programme of work was drawn up so that the parties should not be at work in malarious and horse sickness districts during the summer months.

Medical instructions.

(*a.*) MEDICAL INSTRUCTIONS.

A. *Bathing.*—It is not generally safe to take cold baths in these sub-tropical regions unless under medical advice. Those who do so *ad libitum* run certain risks unless they are in perfect health. It is better to have the water at least so warm as not to give any unpleasant shock on sponging. Warm baths, only, should be taken by those who have suffered from attacks of fever, diarrhœa, dysentery, or from any disease of the liver or other important viscera. Bathing should never be resorted to during the period of digestion, *i.e.* 3 to 4 hours after meals.

B. *Clothing.*—Wear warm clothing at night next the skin. Flannel or its equivalent should also be worn next the skin during the day. Two or more woollen shirts are more efficient for giving warmth than a single coarse one. At night sleeping socks should also be worn.

C. *General.*—Never begin work on an empty stomach. Avoid the direct rays of the sun in summer as much as possible, and never leave shelter while the sun is shining without a head covering.

Never neglect slight attacks of fever or diarrhœa. Avoid all chills, draughts, and wetting as much as possible, and also heavy meals during the heat of the day.

D. *Cooking.*—All meat and vegetables should be well cooked. Imperfectly cooked meat renders you liable to tape-worm and other entozoa.

E. *Thirst.*—Very cold water, or any other water drunk in large quantities is injurious. Your thirst can be satisfied as well by drinking slowly and in small quantities as by drinking quickly and taking large quantities. It is advisable always, to drink no water but that which has been boiled, better in the shape of tea or coffee, unless the source is above suspicion, which it probably rarely is in any country except in towns which are provided with a regular supply of water.

F. *Milk.*—All milk should be boiled and then kept in a bottle thoroughly cleaned out with boiling water and stoppered by a cork, also boiled.

Condensed milk should always be mixed with boiling water, and not put into either tea or coffee directly. But both tea and coffee, cold and weak, without milk, are least injurious of all drinks, provided the system gets sufficient exercise.

G. *Native drinks.*—Avoid all native drinks, of whatsoever kind, as they will probably have been made or diluted with dirty water, or prepared in unclean vessels.

H. *Mosquito curtains.*—Some form of mosquito curtain, made to suit the conditions of the tent, should always be used. They serve to keep off the flies in the daytime, and mosquitoes at night. It is the bite of the latter which gives rise to malaria and similar fevers.

I. The following are the common ailments likely to be met with in the field:—

1. *Diarrhœa,* or looseness of the bowels, usually due to the presence of some irritant in the bowels, such as bad or uncooked food, unripe fruit, etc. If not excessive, however, it may really be beneficial and will wear itself out. But if excessive and lasting some days, it requires medical attention. Keep on light diet and start treatment by taking one ounce of *Castor Oil,* to be followed after a short interval by one grain of *Opium.* If the diarrhœa continues, take *Chlorodyne,* 20 minims (drops), and *Tincture of Ginger,* 10 minims, in an ounce of water three times a day. If diarrhœa is persistent, the nearest medical advice

should be obtained. But you should try the diarrhœa mixture made up as follows:—

Sodae Bicarb., 60 grs.; Liq. Bismuthi, 1 oz.; Liq. Morph. Hydro-Chlor., 60 minims; Tinct. Chloroform Co., 120 minims; Aquae Cinamin, ad. 6 oz. One table-spoonful after each meal.

2. *Dysentery* is distinguished from diarrhœa by bloody stools, and the frequency of calls, passage of mucus, or blood and mucus, etc., and pain and straining at each motion.

   The best thing to do is to go to bed and take 15 grains of *Sulphur* every three hours until the blood ceases, then take 10 grains every four hours till the other symptoms disappear. Keep on a milk diet if possible, exercising the precautions as to the forms of milk and as to water already given, and wear flannel over the abdomen. If no sulphur at hand, take two tea-spoonfuls of *Epsom Salts* in a cupful of water every three hours till the symptoms abate. In severe cases amenable to neither treatment, you should send for nearest medical advice.

3. *Typhoid Fever* is indicated if there is continuous fever for three or four days, accompanied by severe headache, diarrhœa, or constipation, both pronounced. Go to bed, take a dose of one ounce of *Castor Oil* and five grains of *Quinine* daily. But always send for a doctor, or go to the nearest hospital. *No* food but milk, and absolute quiet in bed.

   Associated with this disease is the appearance of a rose-coloured rash on chest and abdomen, disappearing on pressure—but it does *not always* occur; probably in about 10 per cent. of cases there is no rash. The rash is not easily recognised unless it has been pointed out, but it should always be looked for in suspicious cases.

4. *Malaria* is characterised by a cold stage (shivering), a sweating stage, and a hot stage. Directly you feel these symptoms commencing, take an aperient of four grains of *Calomel.* Then wait for the sweating stage, and take a dose of 15 grains of *Quinine,* followed by 10 grains three times a day for four days. After ceasing the quinine, take a tabloid of *Iron and Arsenic* for two or three weeks, missing one day a week, on which take a dose of *Epsom Salts,* two tea-spoonfuls in a cupful of water in the morning before breakfast, and three 5-*grain Quinine* tabloids during the day.

5. *Coryza,* or cold in the head, can usually be cut short by retiring to bed early, taking 10-grain dose of *Dover's Powder,* and covering yourself with as many additional bedclothes as can be borne. The perspiring effect may be increased by taking hot lemonade, hot tea, or even hot water. Special care must be taken to avoid chill on the following morning.

6. *Prickly Heat* is caused by free sweating, and is accompanied by intense heat and itching.

   Avoid copious consumption of fluids, moderate your exercise or keep it under proper control, and avoid anything which leads to profuse perspiration. At the beginning of an attack, take a good saline purge. Then take *Bi-carbonate of Soda* three times a day in 10-grain doses. To relieve the itching, carefully dry the skin and dust it well over the itching parts with a powder made up of equal parts of *Boric Acid, Zinc Oxide,* and *Starch,* or apply a *Carbolic Acid Lotion,* a table-spoonful of *Carbolic Acid* to a quart bottle of water. Wear thin flannel.

7. *Tapeworm* is the direct consequence of eating imperfectly cooked meat. The worms measure many feet in length, made up in segments which are cast off in the bowel and thrown out in the fæces, and their presence within the body is only certainly known in this way. The segments are white in appearance like bits of boiled macaroni, and may often be seen on the fæces of Kaffirs, who are always more or less troubled by them. For two days prior to the administration of the remedies, as given below, keep on very light diet, and have the bowels moved by a saline purge. Take a good aperient overnight so as thoroughly to empty the bowel, and take nothing to eat for eight hours at least. Then take 120 drops (2 drachms) of the liquid extract of *Male Fern* in milk; follow this up in four hours by a good meal, and this by a brisk purgative to drive out the worm. The operations serve, first, to starve the worm, then to kill it so that its hold on the intestinal coats is loosened, and finally by means of the mechanical agency of the food to drive it out.

   Another remedy is sometimes very efficient. Get some *pumpkin seeds*, bruise three or four ounces, and macerate in water for 12 or 14 hours. Take the entire quantity as one dose, and follow in an hour by a purge. The preliminary treatment is the same as for the *Male Fern.*

J. *Climbing mountains,* with or without loads. In all climbing operations, the first, and probably continuous, sense of discomfort is in the loss of breath. The meaning of this loss of breath is, that the active exercise involved makes a drain on the blood for the nutrition of the muscles which are being worked, and insufficient oxygenation of this blood compels an increased beating of the heart to force a larger quantity of blood through the lungs, which themselves are put to the strain in compelling quicker breathing.

The whole art in carrying on any hard exercise is to keep the blood sufficiently oxygenated, and this is best and most comfortably done by breathing *deeper* and *more frequently* in exact proportion to the exercise involved. If, with this increased breathing, you still get out of breath, breathe for a few seconds as fast as you can; the sense of discomfort will quickly pass, and, in course of time, you will accustom yourself to breathe in proportion to the call made upon you, and find it as easy to climb a mountain as to walk on a level road, provided you are muscularly fit otherwise.

Horse sickness.

(*b.*) HORSE SICKNESS.

A. Horse sickness, which effects both horses and mules, is prevalent during the summer months throughout the country, appearing shortly after the beginning of the rains in the summer (October to May), but is chiefly confined to the low- and bush-veld, especially at all low altitudes. It disappears suddenly at the beginning of the winter season (May to October), and eight days after the first frost has set in, it is usually extinct as an epidemic, although cases may occur till after the second frost.

B. There are two forms of the disease, one of which (Dunkop) chiefly attacks the lungs, and the other (Dik-kop) the heart. The *symptoms of the first* are that the animal is obviously suffering from want of air; the respiration is hurried; all available muscles to expand the lungs come into action; the stomach is tucked up; the ribs move forward and backward; the forelegs are extended as well as head and neck; nostrils expanded; sweating all over the body; a discharge from both nostrils, at first slightly yellow, brought up at intervals by coughing, and, finally, whitish-yellow foam thrown out by shaking the head and neck, after which the horse usually dies, staggering before dropping.

C. The *symptoms of the second* are that it begins exactly in the same way as the Dunkop except that the lung troubles do not set in so vehemently. The typical symptom is a swelling which appears, as a rule, first above the eye, the cavities looking as though blown up. The swelling may extend all over the head, down the neck, and even as far as the back. The eyes are pressed partially out of their sockets, are tearful, with glaring aspect, eyeballs protruding.

D. *Prevention.*—No horses or mules are to be allowed to graze, during the horse sickness season, before sunrise, and then not before the dew is entirely off the ground, or after sunset or after dew has begun to fall in the evening. In case any animal shows the foregoing symptoms, he should at once be separated from the others and picketed apart, to *leeward*, at a safe distance, and rubbed over with paraffin. It is not certainly known to what conditions horse sickness is due, but there is strong presumption it is due to the bites of mosquitoes or other insects, although some people suppose grazing on dewy grass may in some way be the cause. The camp should never, therefore, be formed low down in hollows or near the banks of a river, nor near dense woods which might harbour the noxious insects. All the animals should be blanketed at night, whatever the weather.

E. *Treatment.*—There is no certain cure known for the disease, so that the preventive measures above given should never be relaxed. No method of rendering horses immune has yet been discovered. The so-called "salted" animals (that is, animals which have survived an attack) are less liable to get the disease, but when they do it is generally in a very virulent form. The best treatment is to give the animal a good purge—say a tablespoonful of powdered *aloes*—followed after two hours by a dessert-spoonful of *quinine* and two or three smaller doses of quinine on the following day. *In the incipient stages* of the disease this will frequently effect a cure. To allay the pains of inflammation, a quarter of a bottle of brandy, or diluted painkiller, can be given with the quinine. When the discharges begin to issue from the nostrils, open up the lung passages with frequent doses of eucalyptus oil, by means of both nostril and mouth.

NOTE.—Only after the field work was completed did Dr. Theiler, of the bacteriological division of the Transvaal Department of Agriculture, succeed in evolving a serum for horse sickness. This, after severe tests, was found to render most mules immune, and is now largely used. It has not yet been successfully diluted for horses.

ORDINANCE TO COVER ENTRY ON LANDS.

136. The right of entry upon land for purposes of the survey was covered in the Transvaal by the passing of an ordinance (No. 11 of 1903) entitled "An Ordinance to facilitate a Trigonometrical Survey, and to provide for the preservation of Trigonometrical Beacons." In the Orange River Colony no special ordinance was enacted, but the Colonial Secretary of the Transvaal, in his letter 5/17534, dated 6th August, 1903, stated that he had been advised that, for all practical purposes, Sections 15, 21 and 22 of the "Lands and Survey Ordinance, 1903," of the Orange River Colony may be said to give equivalent powers to those contained in the Transvaal ordinance, except that the Transvaal ordinance confers greater powers, in that injury can be done provided compensation is paid, whilst in the Orange River Colony nothing put upon land by the owner or occupier for a useful purpose can be removed. On the other hand, the Orange River Colony ordinance permits the use of natural material both for beacons and trigonometrical stations, whereas the

Entry on land.

Transvaal ordinance allows the use of material found on the land, but for beacons only. Should the time ever come when a joint comprehensive survey of the two Colonies is carried out, it would be satisfactory if their ordinances were amended to give similar powers in both.

Claims for damage.

137. The survey has been fortunate in having had practically no trouble in the field as regards entry on land, either for access to a trigonometrical station or for camping purposes. Compensation for damage done has only been claimed in two instances, both in the Orange River Colony, and both for trees cut down which obstructed the view to and from other stations. On the first occasion the compensation ultimately agreed to was paid; the second is still under consideration.

RAIL TRANSPORT.

Extent to which used.

138. Rail transport has been largely used for the conveyance of the field parties, either to start them on their work or to move them from one starting point to another when at great distances apart, and there is no doubt that a considerable saving of money and time has been effected thereby. The base-line party was the one which benefited most by this mode of transport, in that its equipment in road transport was only sufficient for its actual needs during the measurements. The additional road transport required to carry its large personnel and their baggage, as well as the instrumental and other equipment, would have necessitated a larger initial as well as current expenditure. For such travelling by road as it had to do, from the rail terminus to the base-line site, the necessary additional transport was obtained locally by previous arrangement while the sites were being selected.

Expenditure.

139. The actual expenditure on rail transport has been £2,722 6*s.* 3*d.*, made up as follows—the period covered being from October, 1902, to June, 1906 :—

	£	*s.*	*d.*	£	*s.*	*d.*
Headquarters (Office)				129	2	5
Base-line measurement				927	12	5
Base-line reconnaissance				118	1	9
Observing :—						
Superintendent.. ..	208	5	7			
No. 1 observing party ..	236	5	6			
„ 2 „ „	254	16	0			
				699	7	1
Reconnaissance :—						
No. 1 party	134	10	4			
„ 2 „	57	2	8			
„ 3 „	122	0	2			
				313	13	2
Beaconing :—						
No. 1 party	90	4	11			
„ 2 „	86	11	8			
„ 3 „	35	18	1			
„ 4 „	87	15	3			
				300	9	11
Subsidiary chains :—						
Reconnaissance and observing	75	0	4			
Beaconing	19	16	7			
				94	16	11
Levelling party				167	1	8
Total (1902–06)				£2,750	5	4

This represents the total sum paid over to the Railway Department out of survey funds, and includes all rail charges under the various heads. The railway expenses for 1906–7 will probably not exceed £15.

Base-line party.

140. It is only necessary to refer in detail to the transport charges in respect of the base-line party. It is premised :—

1. That had the party been equipped for movement entirely by road, the additional cost would have been at the rate of £3 10*s.* per diem for the extra numbers of natives and mules required.
2. That their road travelling would have been at the rate of 25 miles per day, with a rest of one day after six days' continuous trekking, and on reaching its destination.
3. That the daily cost of the party on the lower establishment was £20⅛, obtained by dividing the total current expenditure below by 15 months in days.
4. That the base-line party was in existence for 15 months, April, 1903, to July, 1904.

Movement		Rail and Road.		Road alone.	
From	To	Miles.	Days.	Miles.	Days.
Belfast	Ottoshoop.. ..	Rail 1,070 Road 24	7	815	15
Ottoshoop ..	Wepener	Rail 688 Road 72	11	384	18
Wepener.. .	Kroonstad.. ..	Road 48 Rail 167	5	181	8
Kroonstad ..	Houts River ..	Rail 339 Road 24	6	410	19
Houts River ..	Pretoria	Road 24 Rail 177	3	206	8
Totals		Rail 2,441 Road 192	32	1,496	68

This shows a saving of 36 days in time.

The cost of the party during 15 months and 36 days at a daily expenditure of £23⅝ would have been—

				£
	£11,726	Current expenses...	...	9,274
		Special transport :	£	
		Rail... ...	928	
Total cost of current plus special expenses is ...	10,660	Other ...	458	1,386
Saving	£1,066			£10,660

There is the further consideration as to the loss in depreciation of the extra transport vehicles and animals, which is not included, but which may be assessed at, approximately, £500.

GROUND STANDARDS OF LENGTH.

Ground standards.

141. A not unimportant part of the survey work has been the laying down of the Ground Standards of length, with which Surveyors' chains and tapes may be compared from time to time. The standards laid down are :—

A. Bar measures of 50, 100, and 150 Cape feet in the New Government buildings at *Pretoria*.

B. Wire measures of 150, 300, 400, 500, and 600 Cape feet on the Race Course at *Pretoria*.

C. Bar measures of 50, 80, and 100 English feet, and 50 Cape feet, and wire measures of 150, 300, 400, and 500 Cape feet in Joubert Park, *Johannesburg*.

Final lengths.

142. The final lengths of the foregoing standards are as follows :—

	Terminal.	Length.
A.	0 Cape feet.	0·0000 Cape feet.
	50 „	49·9974 „
	100 „	100·0030 „
	150 „	150·0004 „
B.	0 Cape feet.	0·0000 Cape feet.
	150 „	149·9985 „
	300 „	299·9956 „
	400 „	399·9979 „
	500 „	499·9977 „
	600 „	599·9965 „
C.	0	0·0000
	50 English feet.	50·0003 English feet.
	50 Cape „	50·0119 Cape „
	80 English „	79·9932 English „
	100 „ „	99·9995 „ „
	0 Cape feet.	0·0000 Cape feet.
	150 „	150·0014 „
	300 „	300·0017 „
	400 „	400·0011 „
	500 „	500·0041 „

Measurement and marking terminals.

143. The long standards measured with Jaderin wires were treated as miniature base lines in every respect, and measured in a similar way except that the bar standards for comparison of the wires were not so long.

The terminals of the standards are fixed in concrete blocks sunk flush with the ground, the ground surface along the entire length being specially prepared to admit of easy comparison of chains and tapes.

Offer to other colonies.

144. It was thought that it would be very advantageous if similar standards were laid down in all the South African colonies, and a letter was addressed to the Imperial Secretary for the favourable consideration of the High Commissioner, pointing out what had already been done in this direction in the Transvaal, and submitting that similar action might be acceptable to other Governments. The suggestion was to utilise the survey staff on the completion of their present work, and before being scattered, to carry out this work at such centres as the colonies might desire, in order that full advantage might be taken of their experience in such work. It was pointed out that the staff proposed to be employed had participated in the measurement of five long base lines having a total length of nearly 70 miles, measured throughout three times, representing over 200 miles of linear measurement; that it was certain that, in the near future, the Jaderin system of measurement by means of metallic wires would entirely supersede the old method by means of steel chains or tapes, that it would then be absolutely necessary to have long ground standards laid down for standardising the wires, and that it would be advantageous for the colonies to anticipate these future requirements by utilising the services of experienced men fresh from their work.

But, unfortunately, like other suggestions savouring of science and accuracy, and progress and development underlying them, the replies from the colonies have been in the negative. Nevertheless, it has been thought to be the duty of the survey to make the suggestion, and to put it on record.

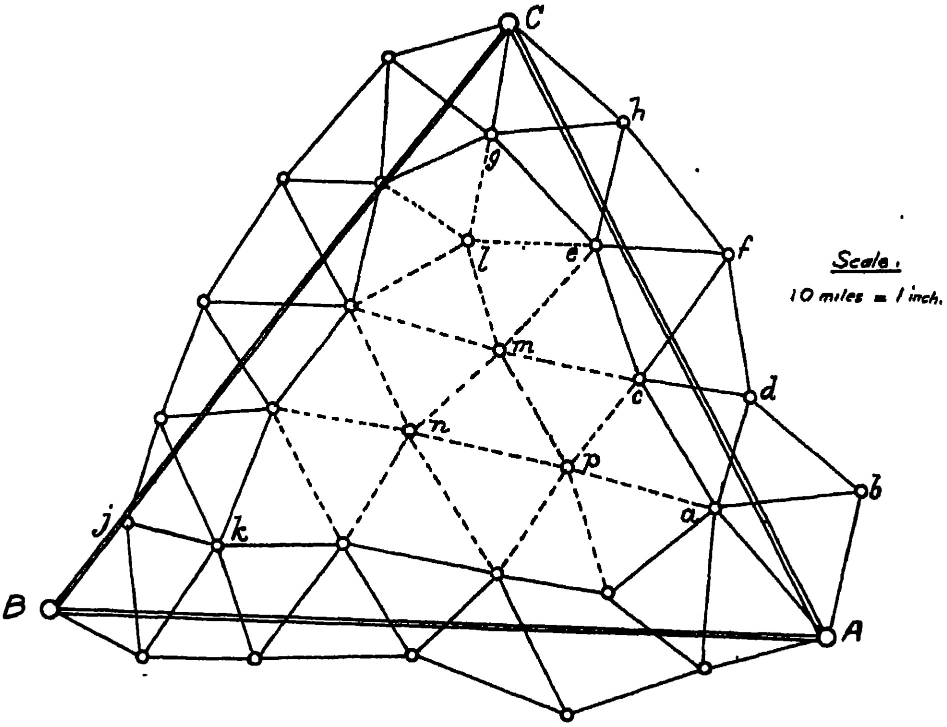
ONE METHOD OF RENDERING A SECONDARY TRIANGULATION CONFORMABLE TO THE PRIMARY.

Secondary points in relation to primary.

145. Let the triangle ABC represent a triangle of the primary chains, so that it is fixed in all respects. Let *a*, *b*, *c*, &c., be the points of secondary chains running in the direction of the primary lines.

Observations would be taken with sufficient accuracy by means of a 6-inch theodolite provided with micrometers for reading the horizontal circle at all the secondary points among themselves, and these are all that are necessary.

Starting, then, at A, the chain along AC would first be made conformable to that line; next, the chain along AB would be similarly treated; and, finally, the chain between B and C would be made conformable to that line, as well that the lines C*g* and B*k* would be taken as fixed. There would then only remain to fix the position or positions of any points such as *l*, *m*, *n*, *p*, with reference to the fixed points surrounding. In this way the whole of the primary chains would be filled in with secondary work which would be rigidly fixed.

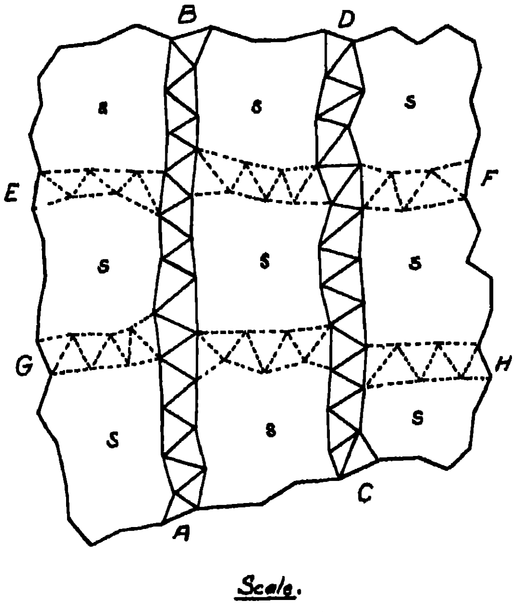


Secondary chains in relation to primary.

146. In order to fill in the spaces contained within quadrilaterals, or closed circuits, of the primary chains, the same principle of working from whole to part might be applied as follows:—

Let the thickened irregular line represent the inward series of secondary lines filling up the primary chains as described above. Then, depending on the area of the enclosed space, one or more secondary chains, such as AB, CD, would be run meridionally, which would be made conformable to their terminal sides. Next, longitudinal chains, such as EF, GH, would be run and made to conform in a similar way at their terminals and at their junctions with those along the meridian. There only remain the small enclosed spaces, *s*, to fill in with triangulation, and fix them with reference to the foregoing.

In this way the geometrical conditions are fulfilled in a simple and expeditious manner, and the rigidity of the work ensured from step to step with a complete control over any tendency to the accumulation of errors.



Calculations.

147. The computations involved are quite simple, and not too laborious for the result to be obtained. As an illustration of the method in its early stages, a chain of points was selected connecting the trigonometrical station at Cable

Hill (Pretoria) with that at Observatory Hill (Johannesburg). The observations were made with a 6-inch theodolite by Messrs. Troughton and Simms. The chain was eventually connected with the Rand triangulation in order to bring in the results of a previous determination of latitude and longitude for comparison with the results of the new survey.

A full report of the calculations involved, and the general results, appears in the Appendix to Mr. Robinson's report (page 198).

PHOTOGRAPHS.

Illustrating report by photographs.

148. An attempt has been made to illustrate the report with photographs of the more important instruments used, as shown in the list below :—

No.
1 & 2. Repsold theodolite (near view).
3 & 4. Repsold theodolite on its portable stand.
5 & 6. Levelling instrument on its tripod.
7 & 8. Levelling instrument (near view).
9. Theodolite stand on ring.
10. Transferring apparatus.
11. Pulley wheel of straining pole.
12. Straining pole and weight suspended.
13. Tripod of Jaderin base apparatus.
14. Temperature scale for standardiser.
15. Method of holding levelling staff in the field.
16. Drums for concrete beacons.
17. Preceding terminal of Jaderin wire with observers.
18. Following terminal of Jaderin wire with observers.
19. Jaderin wires, working with, in the field.
20. Repsold theodolite on concrete pillar in hut, showing arrangement of bullseye lanterns for astronomical observations.
21. Bar comparison apparatus in hut.
22. Standardiser for levelling staves.
23 & 24. Stereoscopic view of Repsold theodolite.
25. Stereoscopic view of levelling instrument.
26. Terminal of standardiser of levelling staves, where brass and steel rods have free expansion or contraction.
27. Micrometer terminal of above.
28. " Coudé " microscope of standardiser in position.
29. Instrumental details of Jaderin apparatus.
30. Photograph of the Survey Staff.

The stereoscopic views are so arranged that similar points on the two pictures are 2½ inches apart, which is less than the average distance between the two eyes, and so can be viewed stereoscopically, by a little practice, without the aid of a stereoscope. Perhaps the following explanation will help to this end :—

When looking at a very distant object the axes of the two eyes are practically parallel to each other. If now, while steadily viewing the distant object, the index finger is held up before the eyes, two images of it are seen, corresponding to the two eyes. Now bring up the index finger of the other hand, when four images will be seen. Then, by moving the fingers a little, the two central images can be superposed, leaving only three images visible. The result of this is that the right-hand image of the left-hand finger, as seen by the left eye, is superposed on the left-hand image of the right-hand finger as seen by the right eye. When the stereoscopic picture is substituted for the fingers, similar results follow, and when the two inward images of the pictures are superposed it is being viewed in exactly the same way as it was viewed by the two lenses of the camera and projected on the sensitive plate. The difficulty always is, in first attempts, to maintain the parallelism of the axes of the two eyes, but a little practice and some mental effort soon allow of this being done. It is becoming the accepted practice now to photograph pathological and other conditions stereoscopically, so that the objects may be viewed with the eyes as the eyes view them directly, and thus to give them a solidity which a single photograph cannot do.

SURVEY OFFICE.

Location of office.

149. The Trigonometrical Survey Office was first established in the new public buildings in Pretorius Street, Pretoria, where it remained during 1903. But as only one small room was available, and as stores began to accumulate, it was found necessary to increase the accommodation. A suitable dwelling house was hired in Jubilee Square, containing four rooms as offices, and two as store rooms, into which the personnel and stores were moved in December, 1903, since which it has been the headquarters of the survey.

Field records.

150. The total number of field record books is 148, as shown in Table V, in which they are classed as follows :—

		Nos.
a	Base-line records	1–15a
b	Ground standards	16–18
c	Comparison of bars	19–23
d	Horizontal and vertical angles	24–67
e	Astronomical observations	68–76a
f	Geodetic levelling	77–144a
g	Miscellaneous	145–148

Each book or packet bears a number and a label stating its contents, so that any particular part of the work may be found for future reference without any trouble.

Computation records.

151. The records of all the calculations connected with the survey are made up and numbered as given in Table W, in which they are classed as follows :—

BOOKS.

		Nos.
a	Base lines	1–9
b	Horizontal angles	10–14
c	Vertical angles	15–18
d	Computation of triangles	19 & 20
e	Circuit solution	21–26
f	Astronomical	27 & 28
g	Geodetic levelling	29–34
h	Rough field computations	35–37

PAPERS.

j	Base lines	38 & 39
k	Horizontal angles	40 & 41
l	Vertical heights	42
m	Probable errors	43
n	Circuit solution	44–46
o	Astronomical	47 & 48
p	Bars	49
q	Geodetic levelling	50 & 51
r	Swaziland triangulation	52

Tables.

152. The following is a list of the Tables contained in the reports. Those from A to N are incorporated in Mr. Robinson's report. The remainder are placed at the end of the report as a whole, and are followed by the descriptive list of stations and the final results of the survey :—

A. Observed angles and their corrections.
B. Triangular errors.
C. Co-ordinates of station on the line of traverse.
D. Values of P and Q used in the computations.

E. Values of coefficients and absolute terms.
F. Resulting corrections.
G. Values of P and Q in supplementary adjustment of chains *a*, *b*, *c*.
H. Values of coefficients and absolute terms of chains *a*, *b*, *c*.
J. Resulting corrections, adjustment of chains *a*, *b*, *c*.
K. Arbitrary corrections for circuit closure.
L. Final co-ordinates of stations in circuits.
M. Coefficient of refraction determined from mutual vertical angles.
N. Resulting corrections to the differences of height.

O. Separate lengths of bars.
P. Combined lengths of bars.
Q. Table of logs. M, N, and E.
R. Table of log. constants *k*, F, G, H, J, P, and C.
S. Distances from the 25th parallel.
T. Astronomical azimuths.
U. Astronomical latitudes.
V. List of field record books.
W. List of computation records (books and papers).

Diagrams.

153. The diagrams accompanying the report are enclosed in tins. Reference is made to them in the covering letter addressed to the Secretary, Inter-Colonial Council.

Office records.

154. The office records connected with the survey are made up and numbered as given in Mr. P. C. Morgenrood's report, as follows:—

301–337. Red letter files of correspondence.
338–351. Books referring to expenditure, equipment, stores, and correspondence.
352–356. Letter books.
357–372. Manifold books (minor correspondence).
373–382. Telegram books.
383–395. Order books for stores, etc.
396 onwards. Miscellaneous.

Field reports, sketches, and maps.

155. The records of field reports on trigonometrical stations and roads connecting them, as well as of the maps on which the triangulation was drawn as the work progressed, are similarly numbered, indexed, and arranged in sets as follows:—

A. Trigonometrical stations, separated into eight groups.
B. Outline sketches of distant country, from stations.
C. Road reports, Group III to VIII.
D. Sketches to scale of trigonometrical points and surroundings.
E. Maps.

156. A general index to the trigonometrical stations, for the printed report, has been drawn up, and is attached to this report. It cannot be completed until all the work is in print. Only one copy is needed, and that copy has to go to England.

W. G. MORRIS, Colonel,
Superintendent Trigonometrical Survey.

REPORT OF MR. W. B. ROBINSON ON COMPUTATIONS AND RESULTS OF SURVEY.

REDUCTION OF BASES TO MEAN SEA LEVEL AND PROBABLE ERRORS OF REDUCED BASES.

1. The adopted mean heights of the bases depend on the heights of the terminals, obtained through the adjusted vertical angles, and upon the levelling during the measurement. The data and results are given in the following table:—

Base.	Mean Height.	Measured Lengths.	Reduction to M.S.L.	Reduced Lengths.		Log. Eng. ft.	Value of Log. used in computations.
	Eng. ft.	Metres.	Metres.	Metres.	Eng. ft.		
Belfast ..	6,326	18,994·055	—5·754	18,988·301	62,298·18	4·7944750	4·7944751
Ottoshoop..	4,690	17,438·205	—3·917	17,434·288	57,199·62	4·7573931	4·7573932
Wepener ..	4,879	21,655·345	—5·058	21,650·287	71,031·77	4·8514526	4·8514527
Kroonstad	4,547	19,836·131	—4·819	19,831·812	65,065·58	4·8133518	4·8133512
Houts R. ..	3,991	33,969·349	—6·494	33,962·855	111,427·72	5·0469932	5·0469931

Probable Errors of the Reduced Bases.

2. In addition to the sources of theoretical probable error discussed in Mr. Simms' report, there are :—

(*a*) The errors in the reduction to sea level due to the errors in the adopted heights (*see* paragraph 21).

(*b*) The systematic errors discussed by Sir David Gill in the "Report on the Geodetic Survey of South Africa," vol. I, p. 65. These are: the probable error of the Standard Bar, the probable errors in the Comparison of the Base Bars with the Standard, and the probable systematic errors of the thermometer zero. Sir David Gill estimates the probable combined effect of these systematic errors at ± 1·065 μ where μ is one millionth part of the length.

The combined effects of the systematic and accidental errors on the probable errors of the lengths of the reduced bases are tabulated below:—

Base.	Probable effect of systematic and accidental errors in measurement.	Probable effect of errors of Height.	Probable effect of systematic errors of Bars and Thermometers.	Probable error of Base.		
	μ	μ	μ	μ	mm.	inches.
Belfast.. ..	±0·725	±0·278	±1·065	±1·318	±25	±1·0
Ottoshoop ..	±0·526	±0·383	±1·065	±1·248	±22	±0·9
Wepener ..	±0·295	±0·484	±1·065	±1·206	±26	±1·0
Kroonstad ..	±0·311	±0·436	±1·065	±1·192	±24	±0·9
Houts R. ..	±0·526	±0·354	±1·065	±1·239	±42	±1·7

Reduction of Measures of Horizontal Angles.

Methods adopted.

3. (*a*) In the reduction of the measures of the horizontal angles, the methods adopted in the survey of Cape Colony were closely followed.

Circle divisions and micrometers.

(*b*) The horizontal circles of the Repsold theodolites are divided into 4-minute spaces, and are read by two microscopes, the screw-heads of which are divided into 60 parts. Two revolutions of the screws correspond approximately to 4 seconds of arc, therefore each division of the head equals 2 seconds. The whole revolutions of the screw were recorded as minutes, and the divisions of the head as seconds. Thus, in order to obtain the mean of the micrometer readings in true minutes and seconds, the recorded readings of the two micrometers are added together. The micrometers were read with the right-hand wire bisecting the reading division, and the left-hand wire bisecting the run division. The angular interval between the two sets of wires was determined at each station.

Run.

(*c*) The correction for run was obtained by combining the readings during the observation of horizontal angles with this determination of the wire interval, as follows :—

Let W = Wire interval (excess in recorded seconds),
R = Reading of right hand wire,
L = Reading of left hand wire ;

then the correction for run for a recorded one minute space is ((L − R) − W), in true seconds of arc. The correction was supplied to the mean reading of the micrometers, and the factor for each microscope to be multiplied by the recorded minutes, is therefore

$$\tfrac{1}{2}\,((L - R) - W).$$

Level.

(*d*) The level readings were always recorded, but the level corrections were, in general, too insignificant to be applied.

Watch and sight.

(*e*) The corrections for the readings of the watch and sight telescopes were applied differentially for each point observed in any one arc, the left-hand point being the point of reference.

Horizontal angles.

(*f*) The angles in the chain Kimberley to Ottoshoop and in the tie-chain through Klerksdorp to Kroonstad were measured on four arcs only. All other angles in the primary chains were measured on eight arcs. In column 3 of Table A will be found the results of the angles thus measured. In addition, this table contains the observed angles of all the triangles in the Cape Colony and Natal Surveys which were included in the adjustment of circuits, together with all figural, circuit, and non-circuit corrections, and the seconds of the finally corrected angles. The derivation of the corrections is given later on in considering the adjustments of figures and of circuits. Table A also contains the angles and their corrections, of triangles in the secondary chain between Pretoria and Johannesburg, measured by Captain Gordon and Mr. A. Cochrane with 6-in. and 8-in. theodolites.

Triangular errors.

(*g*) Table B gives the sums of the corrections to the angles, the triangular errors of all the triangles, and the probable error of a single observed angle for each section. The magnitude and distribution of the errors of triangles, and of the corrections to the angles, may be given here. The errors of triangles and the probable errors of a single angle are given for each observer, and the corrections to angles for each chain. Only triangles measured for the Survey of the Transvaal and Orange River Colony are considered.

(*h*) ABSTRACT OF TRIANGULAR ERRORS.

Range of errors of triangles, and probable error of a single angle.

Observer.	No. of triangles.	Limits of errors of triangles.						Probable error of a single angle.
		″ 0·0 to 0·5.	″ 0·5 to 1·0.	″ 1·0 to 1·5.	″ 1·5 to 2·0.	″ 2·0 to 2·5.	″ 2·5 to 3·0.	″
Captain Gordon	102	54	35	8	2	2	1	±0·30
Mr. Simms	87	36	35	15	1	..	..	±0·29
Captain Ley	71	23	21	19	6	2	..	±0·39

Thus the probable error of a single angle, measured on eight arcs, is ... ... ± 0″·30

and the probable error of a single angle, measured on four arcs, is ... ... ± 0″·39

(*i*) RANGE OF CORRECTIONS TO HORIZONTAL ANGLES.

Range of corrections to horizontal angles.

Chain.	″ 0·0 to 0·25	″ 0·25 to 0·5	″ 0·5 to 0·75	″ 0·75 to 1·0	″ 1·0 to 1·25	″ 1·25 to 1·5	″ 1·5 to 1·75	″ 1·75 to 2·0	″ 2·0 to 2·25	″ 2·25 to 2·5	No. of angles.
Newcastle–Belfast ..	60	30	17	7	1	2	..	..	..	..	117
Belfast–Ottoshoop ..	25	17	10	2	2	1	..	..	..	..	57
Johannesburg–Kroonstad	45	39	4	5	..	..	..	..	..	..	93
Kroonstad–Wepener ..	51	25	15	3	1	..	..	..	..	..	95
Wepener–Oala	4	6	3	2	1	2	..	..	..	..	18
Hopetown–Wepener ..	16	12	2	3	..	..	..	..	..	..	33
Kroonstad–Newcastle ..	16	7	1	..	..	..	..	..	..	..	24
Kimberley–Kroonstad* ..	37	12	4	1	..	..	..	..	..	..	54
Kimberley–Ottoshoop† ..	82	52	26	17	5	1	1	..	..	1	185
Tie–chain	6	11	7	2	2	1	1	..	..	..	30
Belfast–Limpopo	43	25	8	2	..	..	..	..	..	..	78
Total	385	236	97	44	12	7	2	..	..	1	784
Excluding Captain Ley's angles	297	173	64	25	5	5	..	..	..	..	569

* Including 15 angles in Hopetown to Kimberley list.

† „ 14 „ „ „ „

(*k*) Following Table B are given the data for reduction to the centre of a station, when the instrument or signal was eccentrically placed.

Reductions to centre.

Table A.

OBSERVED ANGLES AND THEIR CORRECTIONS.

King William's Town to Newcastle.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Bekruip Kop..	3	58	22	16·84	− ·17	+ ·67		17·34
Breakfast Vlei	1	70	51	16·29	− ·17	+ ·68		16·80
Hogsback	2	50	46	34·12	− ·17	−1·35		32·60
Berlin	5	73	5	4·41	+ ·71			5·12
Hogsback	2	15	19	53·46	− ·08			53·38
Bekruip Kop..	3	91	35	3·46	+ ·71			4·17
Gonubie	4	63	32	60·03	−1·07			58·96
Hogsback	2	43	44	31·46	− ·86			30·60
Bekruip Kop..	3	72	42	37·14	+ ·41			37·55
Gonubie	4	73	28	41·42	−1·06			40·36
Hogsback	2	28	24	38·00	− ·78			37·22
Berlin	5	78	6	48·27	− ·73			47·54
Gonubie	4	9	55	41·89	·00			41·89
Bekruip Kop..	3	18	52	26·31	+ ·31			26·62
Berlin	5	151	11	52·69	− ·03			52·66
Windvogelberg	6	72	27	36·60	+ ·05	− ·15		36·50
Hogsback	2	77	58	7·37	+ ·06	− ·35		7·08
Gonubie	4	29	34	21·41	+ ·06	+ ·50		21·97
Mbulu	7	75	1	48·16	+ ·54	+ ·34		49·04
Windvogelberg	6	48	34	33·81	+ ·55	− ·81		33·55
Gonubie	4	56	23	43·85	+ ·55	+ ·48		44·88
Lubisi	8	57	25	47·42	− ·15	− ·10		47·17
Windvogelberg	6	41	36	49·17	− ·14	− ·15		48·88
Mbulu	7	80	57	30·53	− ·15	+ ·25		30·63
Owecweni	9	57	4	30·73	− ·01	− ·19		30·53
Lubisi	8	51	53	20·59	− ·01	+ ·07		20·65
Mbulu	7	71	2	18·44	− ·01	+ ·12		18·55
Xuka	10	44	31	3·24	+ ·42	+ ·07		3·73
Lubisi	8	60	8	22·68	+ ·42	+ ·66		23·76
Owecweni	9	75	20	40·93	+ ·42	− ·74		40·61
Bazeia	11	83	38	31·35	− ·04	− ·42		30·89
Xuka	10	50	11	25·28	− ·03	+ ·04		25·24
Owecweni	9	46	10	9·29	− ·03	+ ·38		9·64
Viewhill	12	57	30	43·75	+ ·16	− ·30		43·61
Xuka	10	59	33	26·74	+ ·16	+ ·68		27·58
Bazeia	11	62	55	54·00	+ ·16	− ·33		53·83
Ncolora	13	64	18	6·77	+ ·86			7·63
Viewhill	12	61	33	14·46	+ ·09			14·55
Bazeia	11	54	8	43·57	−1·24			42·33
Bele	14	91	21	21·78	− ·57			21·21
Viewhill	12	51	32	16·92	− ·62			16·30
Bazeia	11	37	6	25·49	− ·31			25·18

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KING WILLIAM'S TOWN TO NEWCASTLE—*continued.*								
		°	′	″	″	″		″
Bele	14	151	0	17·68	+1·18			18·81
Ncolora	13	18	58	42·77	+ ·70			43·47
Viewhill	12	10	0	57·55	+ ·70			58·25
Bele	14	117	38	20·54	− ·56			19·98
Bazeia	11	17	2	18·07	− ·93			17·14
Ncolora	13	45	19	24·00	+ ·16			24·16
Nquashu	18	65	18	37·27	−1·06			36·21
Viewhill	12	33	58	1·41	− ·66			0·75
Ncolora	13	80	48	27·25	−1·41			25·84
Ladykok	19	57	27	33·96	+ ·42			34·38
Viewhill	12	57	53	37·04	+ ·11			37·15
Nquashu	18	64	38	53·23	+ ·19			53·41
Ladykok	19	39	50	23·38	− ·01			23·37
Ncolora	13	48	18	4·79	− ·69			4·10
Viewhill	12	91	51	38·46	− ·55			37·91
Ladykok	19	17	37	10·58	+ ·44			11·02
Nquashu	18	129	52	30·49	− ·87			29·62
Ncolora	13	32	30	22·45	− ·71			21·74
Viewhill	12	43	38	58·96	+ ·04			59·00
Nquashu	18	37	37	33·23	− ·77			32·46
Bele	14	98	23	30·27	+ ·59			30·86
Nquashu	18	27	36	4·04	− ·29			3·75
Bele	14	52	36	47·41	+ ·54			47·95
Ncolora	13	99	47	10·02	− ·71			9·31
Bazeia	11	22	2	31·79	− ·91			30·88
Bele	14	88	26	6·77	− ·38			6·39
Nquadu	15	69	31	24·67	− ·54			24·13
Bele	14	29	12	13·77	− ·19			13·58
Nquadu	15	78	29	47·71	− ·23			47·48
Ncolora	13	72	17	59·39	− ·17			59·22
Bazeia	11	5	0	13·71	+ ·02			13·73
Ncolora	13	26	58	35·39	− ·33			35·06
Nquadu	15	148	1	12·38	− ·77			11·61
Gcwengana	16	49	40	49·58	− ·12			49·46
Bele	14	48	53	2·77	− ·24			2·53
Nquadu	15	81	26	8·35	+ ·21			8·56
Umtata	17	21	17	45·17	− ·17			45·00
Bele	14	28	31	50·38	+ ·64			51·02
Nquadu	15	130	10	23·76	+ ·78			24·54
Gcwengana	16	83	2	5·54	− ·20			5·34
Nquadu	15	48	44	15·41	+ ·57			15·98
Umtata	17	48	13	39·14	+ ·08			39·22
Gcwengana	16	132	42	55·12	− ·32			54·80
Bele	14	20	41	12·39	− ·88			11·51
Umtata	17	26	55	53·98	+ ·25			54·23
Insizwa	20	63	12	28·82	+ ·51	− ·55		28·78
Ladykok	19	64	40	52·05	+ ·51	+ ·20		52·76
Nquashu	18	52	6	42·00	+ ·51	+ ·35		42·86

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KING WILLIAM'S TOWN TO NEWCASTLE—*continued.*								
		°	'	"	"	"		"
Jumbla	21	61	55	21·14	·00	− ·22		20·92
Insizwa	20	42	10	34·64	·00	− ·14		34·50
Ladykok	19	75	54	7·41	− ·01	+ ·36		7·76
Jumbla	21	49	33	30·97	− ·12	+ ·45		31·30
Insizwa	20	73	42	11·33	− ·12	+ ·11		11·32
Mount Currie	22	56	44	22·59	− .11	− ·56		21·92
Zwaartberg	24	51	15	5·98	+ ·25			6·23
Jumbla	21	35	49	26·10	+ ·54			26·64
Mount Currie	22	92	55	32·00	+ ·26			32·26
Mungunung	23	114	7	12·01	−1·66			10·35
Jumbla	21	45	47	49·43	−1·11			48·32
Zwaartberg	24	20	5	4·29	+ ·07			4·36
Mungunung	23	71	14	15·81	− ·78			15·03
Jumbla	21	81	37	15·53	− ·58			14·95
Mount Currie	22	27	8	33·58	− ·30			33·28
Mungunung	23	42	52	56·20	− ·88			55·32
Mount Currie	22	65	46	58·42	+ ·56			58·98
Zwaartberg	24	71	20	10·27	+ ·33			10·60
Mount Currie	22	67	45	30·79	+ ·03	+ ·23		31·05
Malowe	25	48	0	9·57	+ ·03	− ·66		8·94
Zwaartberg	24	64	14	23·88	+ ·03	+ ·43		24·34
Hluku	26	62	2	6·02	− ·02			6·00
Mount Currie	22	36	43	41·78	− ·65			41·13
Malowe	25	81	14	17·03	− ·37			16·66
Hluku	26	19	15	51·52	− ·58			50·94
Mount Currie	22	31	3	21·26	− ·20			21·06
Ingeli	27	129	40	50·03	− ·46			49·57
Ingeli	27	83	44	17·44	− ·48			16·96
Mount Currie	22	67	47	3·04	− ·85			2·19
Malowe	25	28	28	43·52	− ·15			43·37
Hluku	26	81	17	57·54	− ·60			56·94
Malowe	25	52	45	33·52	− ·22			33·30
Ingeli	27	45	56	32·59	+ ·02			32·61
Kokstad	28	120	4	35·00	+ ·66			35·66
Mount Currie	22	40	23	27·39	+ ·67			28·06
Ingeli	27	19	31	55·94	+ ·67			56·61
Umtamvuna	29	68	8	48·01	− ·07			47·94
Ingeli	27	26	13	41·16	− ·07			41·09
Hluku	26	85	42	32·56	− ·08			32·48
Malowe	25	75	56	10·51	− ·12	+ ·05		10·44
Zwaartberg	24	32	35	35·39	− ·13	+ ·28		35·54
Mabehlan	30	71	28	17·77	− ·12	− ·33		17·32
Zwaartberg	24	40	10	42·20	+ ·68	+ ·75		43·63
Mabehlan	30	66	41	50·14	+ ·69	− ·52		50·31
Marwaqa	31	73	7	29·49	+ ·68	− ·23		29·94
Mabehlan	30	70	59	53·84	− ·02	+ ·21		54·03
Marwaqa	31	61	19	41·74	− ·02	+ ·40		42·12
Byrnetown	32	47	40	27·67	− ·02	− ·61		27·04

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KING WILLIAM'S TOWN TO NEWCASTLE—*continued.*								
		°	′	″	″			″
Byrnetown	32	103	43	32·02	+ ·07			32·09
Marwaqa	31	28	7	43·62	− ·48			43·14
Zwaartkop I.	34	48	8	46·71	+ ·38			47·09
Inhluzan	33	74	25	36·08	− ·50			35·58
Byrnetown	32	52	30	4·68	− ·11			4·57
Marwaqa	31	53	4	21·92	+1·00			22·92
Byrnetown	32	56	13	27·34	+ ·19			27·53
Zwaartkop I.	34	84	32	9·45	− ·04			9·41
Inhluzan	33	39	14	24·60	+ ·15			24·75
Marwaqa	31	29	56	38·30	+1·48			39·78
Inhluzan	33	113	40	0·68	− ·34			0·34
Zwaartkop I.	34	36	23	22·74	− ·42			22·32
Spioenkop	35	62	24	11·41	+1·07			12·48
Inhluzan	33	90	14	18·23	+ ·11			18·34
Marwaqa	31	27	21	31·38	− ·56			30·82
Marwaqa	31	57	18	9·68	+ ·92			10·60
Spioenkop	35	77	13	56·69	+1·75			58·44
Zwaartkop I.	34	45	27	56·18	− ·59			55·59
Inhluzan	33	51	23	14·98	+ ·66			15·64
Zwaartkop I.	34	85	47	29·36	+1·08			30·44
Mount Gilboa	36	42	49	16·93	− ·44			16·49
Inhluzan	33	78	55	48·45	+ ·99			49·44
Arrochar	37	41	12	22·34	− ·04			22·30
Zwaartkop I.	34	59	51	50·17	+ ·97			51·14
Spioenkop	35	14	49	45·29	+ ·67			45·96
Inhluzan	33	156	5	41·09	+ ·23			41·32
Zwaartkop I.	34	9	4	33·44	− ·17			33·27
Spioenkop	35	75	46	2·58	− ·15			2·43
Arrochar	37	27	4	6·19	+1·26			7·45
Inhluzan	33	77	9	52·64	− ·76			51·88
Arrochar	37	88	59	59·57	− ·30			59·27
Inhluzan	33	27	32	33·47	+ ·33			33·80
Mount Gilboa	36	63	27	28·95	− ·03			28·92
Arrochar	37	47	47	37·23	− ·27			36·96
Zwaartkop I.	34	25	55	39·20	+ ·10			39·30
Mount Gilboa	36	106	16	45·87	− ·46			45·41
Spioenkop	35	60	56	17·29	− ·82			16·47
Arrochar	37	68	16	28·53	+1·22			29·75
Zwaartkop I.	34	50	47	16·73	+1·14			17·87
Morton's Hill	40	157	14	24·55	+ ·28			24·83
Zwaartkop I.	34	8	12	25·12	− ·01			25·11
Mount Gilboa	36	14	33	10·34	− ·01			10·33
Mount Gilboa	36	70	50	25·15	+ ·60			25·75
Morton's Hill	40	70	19	53·08	+ ·74			53·82
Greenkop	38	38	49	40·98	+ ·02			41·00
Greenkop	38	75	46	15·75	− ·71			15·04
Morton's Hill	40	45	39	58·18	− ·40			57·78
Baynes' Hill	39	58	33	47·68	+ ·24			47·92

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KING WILLIAM'S TOWN TO NEWCASTLE—*continued.*								
		°	′	″	″			″
Zwaartkop I.	34	45	46	12·40	−1·23			11·17
Morton's Hill	40	86	45	44·19	− ·61			43·58
Baynes' Hill	39	47	28	6·87	− ·41			6·46
Mount Gilboa	36	85	23	35·49	+ ·59			36·08
Zwaartkop I.	34	30	1	59·87	−1·26			58·61
Greenkop	38	64	34	27·37	− ·43			26·94
Greenkop	38	50	1	29·36	− ·25			29·11
Zwaartkop I.	34	23	56	37·65	+ ·03			37·68
Baynes' Hill	39	106	1	54·55	− ·17			54·38
Mount Gilboa	36	55	52	1·72	+ ·33			2·05
Zwaartkop I.	34	53	58	37·52	−1·24			36·28
Baynes' Hill	39	70	9	23·76	+ ·01			23·77
Greenkop	38	114	35	56·73	− ·68			56·05
Mount Gilboa	36	29	31	33·76	+ ·27			34·03
Baynes' Hill	39	35	52	30·80	− ·19			30·61
Morton's Hill	40	115	59	51·26	+ ·33			51·59
Baynes' Hill	39	22	41	16·88	+ ·43			17·31
Mount Gilboa	36	41	18	51·39	+ ·33			51·72
Greenkop	38	25	44	46·39	− ·45			45·94
Morton's Hill	40	132	25	42·36	−1·01			41·35
Zwaartkop I.	34	21	49	34·75	−1·25			33·50
Baynes' Hill	39	39	45	34·94	+ ·35			35·29
Morton's Hill	40	32	1	54·48	− ·57			53·91
York	42	108	12	31·03	+ ·19			31·22
Morton's Hill	40	48	8	54·35	+ ·51			54·86
Baynes' Hill	39	33	17	24·80	− ·69			24·11
Otto's Bluff	41	98	33	41·28	+ ·21			41·52
Baynes' Hill	39	73	2	59·74	− ·34			59·40
Otto's Bluff	41	42	10	5·94	+ ·37			6·31
York	42	64	46	55·09	− ·33			54·76
Morton's Hill	40	80	5	48·83	− ·06			48·77
Otto's Bluff	41	56	28	35·34	− ·13			35·21
York	42	43	25	35·94	+ ·51			36·45
Otto's Bluff	41	43	34	33·13	− ·24			32·89
York	42	33	10	3·51	− ·94			2·57
Morton's Kraals	44	103	15	26·04	−1·21			24·83
Otto's Bluff	41	52	1	11·02	+ ·04			11·06
York	42	31	5	46·53	− ·04			46·49
Baynes	43	96	53	2·82	− ·07			2·75
Otto's Bluff	41	95	35	44·15	− ·20			43·95
Baynes	43	44	12	35·29	+ ·26			35·55
Morton's Kraals	44	40	11	41·23	− ·52			40·71
York	42	64	15	50·04	− ·98			49·06
Baynes	43	52	40	27·54	− ·34			27·20
Morton's Kraals	44	63	3	44·81	− ·69			44·12
Morton's Kraals	44	43	43	20·95	− ·53			20·42
Baynes	43	32	52	29·31	− ·80			28·51
McKenzie's	45	103	24	12·51	−1·25			11·26

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
King William's Town to Newcastle—*continued.*								
		°	′	″	″	″		″
Morton's Kraals	44	61	9	29·85	— ·75			29·10
McKenzie's	45	68	23	42·74	— ·59			42·15
Kraals	46	50	26	48·95	— ·04			48·91
Baynes	43	62	15	27·32	— ·96			26·36
McKenzie's	45	35	0	29·77	— ·66			29·11
Kraals	46	82	44	4·90	— ·24			4·66
Baynes	43	29	22	58·02	— ·16			57·86
Morton's Kraals	44	17	26	8·90	— ·22			8·68
Kraals	46	133	10	58·85	— ·29			58·56
McKenzie's	45	34	40	45·10	— ·34			44·76
Kraals	46	29	23	44·90	+ ·16			45·06
Roundhill	48	115	55	30·42	— ·18			30·24
McKenzie's	45	24	15	3·03	— ·20			2·83
Kraals	46	18	41	47·87	+ ·40			48·27
Waterfall	47	137	3	8·76	+ ·18			8·94
McKenzie's	45	58	55	48·13	— ·54			47·59
Waterfall	47	68	0	14·45	— ·17			14·28
Roundhill	48	53	3	58·53	— ·36			58·17
Kraals	46	48	5	32·77	+ ·55			33·32
Waterfall	47	69	2	54·31	+ ·35			54·66
Roundhill	48	62	51	31·89	+ ·18			32·07
Waterfall	47	53	7	57·13	— ·17			56·96
Roundhill	48	35	27	49·90	— ·79			49·11
North end Natal Base ..	50	91	24	14·80	— ·85			13·95
Waterfall	47	29	39	1·61	— ·15			1·46
Roundhill	48	27	47	25·28	+ ·05			25·33
South end Natal Base ..	49	122	33	33·27	— ·04			33·23
Roundhill	48	63	15	15·18	— ·74			14·44
North end Natal Base ..	50	44	21	14·39	— ·45			13·94
South end Natal Base ..	49	72	23	31·91	— ·26			31·65
Waterfall	47	82	46	58·73	— ·31			58·42
North end Natal Base ..	50	47	3	0·42	— ·41			0·01
South end Natal Base ..	49	50	10	1·37	+ ·22			1·59
Table Mountain	51	53	56	35·13	+ ·37	+ ·20		35·70
Spioenkop	35	71	20	32·53	+ ·37	+ ·08		32·98
Arrochar	37	54	42	54·91	+ ·37	— ·23		55·05
Umkolumbu	52	56	46	2·11	+ ·45	+ ·01		2·57
Table Mountain	51	40	15	54·69	+ ·45	+ ·12		55·26
Arrochar	37	82	58	5·97	+ ·45	— ·18		6·29
Onderbrook	53	66	34	11·23	— ·26	+ ·15		11·12
Umkolumbu	52	64	15	30·22	— ·27	— ·07		29·88
Table Mountain	51	49	10	24·94	— ·26	— ·08		24·60
Jobskop	54	68	45	44·59	— ·36	— ·02		44·21
Onderbrook	53	48	23	53·42	— ·36	+ ·22		53·28
Umkolumbu	52	62	50	26·73	— ·36	— ·20		26·17
Biggarsberg	55	50	23	31·94	— ·53	+ ·23		31·64
Jobskop	54	76	14	44·58	— ·53	— ·15		43·90
Onderbrook	53	53	21	49·79	— ·53	— ·08		49·18

Table A—*continued.*

KING WILLIAM'S TOWN TO NEWCASTLE—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Noma Hill	56	64	36	27·12	+1·25	+ ·02		28·39
Biggarsberg	55	68	28	9·68	+1·25	+ ·23		10·16
Jobskop	54	51	55	28·40	+1·25	— ·25		24·40
Salt Lake	57	52	18	57·69	— ·24			57·45
Biggarsberg	55	85	15	6·31	+ ·03			6·34
Noma Hill	56	42	25	59·41	+ ·08			59·49
Drakensberg	58	39	11	28·55	+ ·06			28·61
Biggarsberg	55	45	11	9·93	+ ·05			9·98
Salt Lake	57	95	37	24·60	— ·06			24·54
Noma Hill	56	28	38	43·88	— ·16			43·72
Biggarsberg	55	130	26	16·23	+ ·08			16·31
Drakensberg	58	20	55	8·50	+ ·41			8·91
Salt Lake	57	147	56	22·29	— ·30			21·99
Noma Hill	56	13	47	15·53	+ ·24			15·77
Drakensberg	58	18	16	25·05	— ·35			24·70
Inkwelo	59	48	5	24·18*	— ·13	+ ·17		24·22
Salt Lake	57	49	54	29·61*	— ·13	+ ·16		29·64
Drakensberg	58	82	0	10·18*	— ·12	— ·33		9·73
Newcastle	58A	91	19	8·40	— ·01			8·39
Drakensberg	58	48	2	57·63	— ·01			57·62
Inkwelo	59	40	37	55·80	— ·01			55·79

NEWCASTLE TO BELFAST.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Nthabankulu	60	57	10	9·49	+ ·20	— ·28		9·41
Inkwelo	59	65	58	11·61	+ ·20	— ·05		11·76
Salt Lake	57	56	51	44·02	+ ·20	+ ·33		44·55
Langberg I	61	70	51	38·87	+ ·30			39·17
Inkwelo	59	57	56	53·77	+ ·23			54·00
Nthabankulu	60	51	11	31·34	— ·11			31·23
Hlamimpesi Berg	62	31	36	5·37	+ ·50			5·87
Langberg I.	61	116	17	1·48	+ ·67			2·15
Inkwelo	59	32	6	55·67	+ ·20			55·87
Nthabankulu	60	62	32	14·18	+ ·10			14·28
Hlamimpesi Berg	62	72	2	25·64	+ ·51			26·15
Langberg I.	61	45	25	22·61	+ ·37			22·98
Inkwelo	59	25	40	58·10	+ ·03			58·13
Nthabankulu	60	113	43	45·47	— ·01			45·46
Hlamimpesi Berg	62	40	26	20·27	+ ·01			20·28
Elandsberg III.	63	60	1	27·92	— ·69			27·23
Langberg I.	61	93	10	42·57	— ·36			42·21
Hlamimpesi Berg	62	26	47	52·81	+ ·05			52·86
Blaauwkop	64	22	2	49·54	— ·55			48·99
Elandsberg III.	63	116	5	15·62	+ ·30			15·92
Langberg I.	61	41	51	56·81	+ ·19			57·00

* Mean of Col. Morris's and Captain Gordon's observed angles.

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
Newcastle to Belfast—*continued.*								
		°	′	″	″	″		″
Tafelkop (E)	66	41	32	45·38	− ·07			45·31
Elandsberg III.	63	65	22	53·50	+ ·29			53·79
Blaauwkop	64	73	4	25·77	+ ·07			25·84
Spitzkop I	65	88	30	8·05	− ·48			7·57
Elandsberg III.	63	45	50	26·73	− ·01			26·72
Tafelkop (E)	66	45	39	29·83	− ·09			29·74
Hlamimpesi Berg	62	46	24	1·49	− ·42			1·07
Elandsberg III. .. .	63	72	39	56·23	+ ·11			56·34
Spitzkop I.	65	60	56	7·34	− ·12			7·22
Sterkfontein	67	44	34	24·55	+ ·09			24·64
Tafelkop (E)	66	120	58	24·80	+ ·16			24·96
Blaauwkop	64	14	27	12·97	− ·41			12·56
Baatjes Bult	69	22	3	30·53	+ ·21			30·74
Tafelkop (E)	66	42	13	47·09	+ ·24			47·33
Sterkfontein	67	115	42	48·34	+ ·04			48·38
Vlakfontein	68	54	54	56·47	+ ·03			56·50
Tafelkop (E.)	66	32	36	7·58	− ·15			7·43
Baatjes Bult	69	92	28	59·55	− ·09			59·46
Spitzkop I.	65	62	50	26·32	− ·15			26·17
Tafelkop (E)	66	76	59	25·32	− ·09			25·23
Vlakfontein	68	40	10	14·36	− ·33			14·03
Wonderfontein	72	34	26	22·36	+ ·06			22·42
Baatjes Bult	69	90	10	32·82	+ ·26			33·08
Sterkfontein	67	55	23	8·37	+ ·31			8·68
Tafelkop (D.K.)	70	26	15	0·81	+ ·19			1·00
Vlakfontein	68	91	15	7·99	− ·05			7·94
Baatjes Bult	69	62	29	55·56	− ·01			55·55
Verloren Vlei	71	46	49	51·30	− ·10			51·20
Tafelkop (D.K.)	70	74	42	5·99	− ·25			5·74
Baatjes Bult	69	58	28	16·12	− ·17			15·95
Wonderfontein	72	115	57	48·63	− ·73			47·90
Verloren Vlei	71	29	43	33·98	− ·88			33·10
Baatjes Bult	69	34	18	45·87	− ·65			45·22
Panplaats	73	97	39	10·91	− ·23	− ·39		10·29
Verloren Vlei	71	20	8	29·94	− ·23	+1·10		30·81
Wonderfontein	72	62	12	22·26	− ·23	− ·71		21·32
Groot Riet Vlei	79	109	8	41·82	− ·53			41·29
Verloren Vlei	71	25	16	15·68	− ·47			15·21
Panplaats	73	45	35	5·49	+ ·04			5·53
Verloren Vlei	71	60	44	14·42	− ·69			13·73
Belfast	74	53	52	33·87	− ·45			33·42
Groot Riet Vlei	79	65	23	16·56	− ·19			16·37
Belfast	74	86	23	38·61	+ ·43			39·04
Panplaats	73	58	8	25·47	+ ·07			25·54
Verloren Vlei	71	35	27	58·74	− ·23			58·51
Panplaats	73	103	43	30·96	+ ·11			31·07
Groot Riet Vlei . ..	79	43	45	25·25	− ·34			24·91
Belfast	74	32	31	4·74	+ ·88			5·62

Table A - *continued.*

NEWCASTLE TO BELFAST—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″			″
Langekloof	75	153	13	27·09	− ·09			27·00
Belfast	74	18	49	33·92	+ ·38			34·30
Groot Riet Vlei	79	7	56	59·41	− ·29			59·12
Langekloof	75	123	42	23·56	+ ·75			24·31
Panplaats	73	33	23	44·53	− ·21			44·32
Verloren Vlei	71	22	53	53·15	− ·17			52·98
Langekloof	75	132	22	57·31	−1·19			56·12
Verloren Vlei	71	12	34	5·59	− ·06			5·53
Belfast	74	35	2	59·95	− ·83			59·12
Maré's Kop	76	118	51	27·36	− ·05			27·31
Belfast	74	35	42	51·25	− ·02			51·23
Verloren Vlei	71	25	25	42·81	− ·05			42·76
Verloren Vlei	71	37	59	48·40	− ·11			48·29
Maré's Kop	76	83	35	0·72	− ·06			0·66
Langekloof	75	58	25	13·12	− ·62			12·50
Belfast	74	70	45	51·20	− ·35			50·85
Langekloof	75	73	57	44·19	− ·57			43·62
Maré's Kop	76	35	16	26·64	+ ·01			26·65
Groot Riet Vlei	79	57	26	17·16	+ ·10			17·26
Langekloof	75	74	23	35·60	+1·28			36·88
Verloren Vlei	71	48	10	8·83	− ·64			8·19
Langekloof	75	103	54	39·14	+ ·44			39·58
Panplaats	73	24	44	40·94	+ ·28			41·22
Belfast	74	51	20	38·66	+1·26			39·92
Groot Riet Vlei	79	51	42	24·66	− ·63			24·03
Langekloof	75	49	18	47·96	− ·53			47·43
Panplaats	73	78	58	50·02	− ·17			49·85
North end Belfast Base	78	86	44	35·50	− ·18			35·32
Maré's Kop	76	49	28	27·20	− ·35			26·85
Langekloof	75	43	46	57·83	+ ·55			58·38
South end Belfast Base	77	101	14	44·07	− ·46			43·61
Maré's Kop	76	29	36	59·09	+ ·39			59·48
Langekloof	75	49	8	17·73	− ·42			17·31
Langekloof	75	92	55	15·56	+ ·13			15·69
North end Belfast Base	78	32	35	40·48	− ·43			40·05
South end Belfast Base	77	54	29	4·48	+ ·18			4·66
Maré's Kop	76	79	5	26·29	+ ·04			26·33
North end Belfast Base	78	54	8	55·02	+ ·25			55·27
South end Belfast Base	77	46	45	39·59	− ·64			38·95
Rhenosterkop I.	81	15	37	44·97	+ ·94			45·91
Groot Riet Vlei	79	84	27	43·35	+ ·34			43·69
Panplaats	73	79	54	34·71	+ ·34			35·05
Paardekop I.	80	52	42	26·11	− ·03			26·08
Groot Riet Vlei	79	100	39	55·72	− ·16			55·56
Rhenosterkop I.	81	26	37	48·29	− ·47			47·82
Verloren Vlei	71	66	13	32·81	+ ·41			33·22
Groot Riet Vlei	79	65	43	39·12	+ ·35			39·47
Paardekop I.	80	48	2	51·13	+ ·20			51·33

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
BELFAST TO OTTOSHOOP.								
		°	'	"	"	"		"
Quaggafontein	82	90	52	4·80	− ·29	·00		4·51
Paardekop I...	80	55	5	37·01	− ·28	+ ·80		37·53
Rhenosterkop I.	81	34	2	31·00	− ·28	− ·80		29·92
Zwartkloof	83	44	13	49·89	− ·18	−1·21		48·50
Quaggafontein	82	71	1	1·83	− ·17	+ ·38		2·04
Rhenosterkop I.	81	64	45	30·80	− ·18	+ ·33		30·95
Cable Hill	84	82	7	55·17	+ ·04	− ·33		54·88
Zwartkloof	83	43	56	53·29	+ ·04	− ·26		53·07
Rhenosterkop I.	81	53	55	29·66	+ ·04	+ ·59		30·29
Boshofsberg	85	58	50	41·11	+ ·14	− ·58		40·67
Zwartkloof	83	91	10	43·43	+ .13	+ ·03		43·59
Cable Hill	84	29	58	47·58	+ ·13	+ ·55		48·26
Nooitgedacht I.	86	68	23	49·05	− ·29	− ·44		48·32
Boshofsberg	85	35	17	53·18	− ·29	− ·13		52·76
Cable Hill	84	76	18	36·31	− ·29	+ ·57		36·59
Pilandsberg	87	89	58	24·20	·00	− ·26		23·94
Boshofsberg	85	52	50	22·03	+ ·01	+ ·47		22·51
Nooitgedacht I.	86	37	11	29·15	+ ·01	− ·21		28·95
Tafelkop	88	61	47	11·25	− ·24	− ·23		10·78
Pilandsberg	87	53	18	35·51	− ·24	− ·65		34·62
Nooitgedacht I.	86	64	54	30·69	− ·24	+ ·88		31·33
Kaalkop	89	140	1	58·96	+ ·10			59·06
Pilandsberg	87	16	42	44·47	+ ·42			44·89
Tafelkop	88	23	15	24·95	− ·11			24·84
Onverwacht	90	45	42	40·12	+ ·08			40·20
Kaalkop	89	78	3	3·38	+ ·07			3·45
Tafelkop	88	56	14	20·99	+ ·24			21·23
Enzelberg	91	64	22	52·29	− ·13			52·16
Kaalkop	89	82	8	23·07	− ·19			22·88
Onverwacht	90	33	28	48·43	− ·07			48·36
Pilandsberg	87	33	41	39·56	− ·01			39·55
Kaalkop	89	109	46	39·59	+ ·02			39·61
Enzelberg	91	36	31	47·70	+ ·25			47·95
Witkop I.	92	40	38	48·55	+ ·45			49·00
Enzelberg	91	33	16	58·45	− ·29			58·16
Onverwacht	90	106	4	14·33	+ ·14			14·47
Vergenoeg	93	55	27	38·11	+ ·16			38·27
Onverwacht	90	44	30	17·41	+ ·01			17·42
Witkop I.	92	80	2	5·30	+ ·21			5·51
Enzelberg	91	26	17	2·22	+ ·23			2·45
Witkop I.	92	39	23	16·75	− ·24			16·51
Vergenoeg	93	114	19	42·54	− ·15			42·39
Overwacht	90	61	33	56·92	+ ·13			57·05
Vergenoeg	93	58	52	4·43	− ·31			4·12
Enzelberg	91	59	34	0·67	− ·06			0·61
South end Ottoshoop Base ..	95	50	1	8·95	+ ·28			9·23
Vergenoeg	93	17	29	43·09	− ·34			42·75
Witkop I.	92	112	19	8·78	− ·38			8·40

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
BELFAST TO OTTOSHOOP—*continued.*								
		°	′	″	″			″
North end Ottoshoop Base ..	94	26	27	28·32	+ ·20			28·52
Witkop I.	92	78	49	49·76	+ ·37			50·13
South end Ottoshoop Base ..	95	74	42	40·84	+ ·85			41·69
Vergenoeg	93	40	36	31·32	− ·69			30·63
South end Ottoshoop Base ..	95	24	41	31·89	+ ·57			32·46
North end Ottoshoop Base ..	94	114	41	57·74	− ·38			57·36
Witkop I.	92	33	39	19·02	− ·75			18·27
North end Ottoshoop Base ..	94	88	14	29·42	− ·58			28·84
Vergenoeg	93	58	6	14·41	−1·03			13·38
JOHANNESBURG TO KROONSTAD.								
		°	′	″	″	″		″
Observatory Hill (Johannesburg)	96	66	26	16·87	+ ·19	− ·14		16·92
Nooitgedacht I.	86	49	36	35·11	+ ·20	+ ·20		35·51
Cable Hill	84	63	57	15·87	+ ·20	− ·06		16·01
Blijvooruitzicht	97	56	5	29·65	− ·32	− ·08		29·25
Nooitgedacht I.	86	69	8	56·03	− ·33	+ ·24		55·94
Observatory Hill (Johannesburg)	96	54	45	45·29	− ·33	− ·16		44·80
Paardekop II.	98	65	44	6·68	+ ·20	+ ·01		6·89
Blijvooruitzicht	97	29	43	48·52	+ ·21	− ·12		48·61
Observatory Hill (Johannesburg)	96	84	32	11·65	+ ·20	+ ·11		11·96
Witkop II.	99	79	21	27·12	+ ·15	− ·03		27·24
Paardekop II.	98	31	14	37·56	+ ·15	− ·17		37·54
Blijvooruitzicht	97	69	24	2·98	+ ·15	+ ·20		3·33
Elandskop I.	100	63	57	55·58	+ ·07	+ ·04		55·69
Witkop II.	99	61	43	24·20	+ ·08	− ·43		23·85
Paardekop II.	98	54	18	51·84	+ ·08	+ ·39		52·31
Vliegenkraal..	101	69	30	53·81	+ ·35	− ·38		53·78
Witkop II.	99	77	29	29·82	+ ·34	− ·07		29·59
Elandskop I.	100	82	59	42·75	+ ·34	+ ·45		43·54
Spitzkop II.	102	68	42	34·68	+ ·11	+ ·20		34·99
Vliegenkraal.. .. .	101	19	14	10·81	+ ·10	− ·51		10·40
Elandskop I..	100	92	3	18·87	+ ·10	+ ·31.		19·28
Liebenberg Stroom	103	87	24	39·93	− ·60			39·33
Vliegenkraal..	101	25	59	56·77	− ·25			56·52
Spitzkop II.	102	66	35	30·39	− ·12			30·27
Elandskop II.	111	61	55	56·92	+ ·16			57·08
Liebenberg Stroom	103	46	17	25·08	+ ·28			25·36
Spitzkop II.	102	71	46	39·73	+ ·11			39·84
Kaffir Kop	112	38	4	27·71	− ·02			27·69
Liebenberg Stroom	103	62	35	46·02	+ ·06			46·08
Elandskop II.	111	79	19	51·12	− ·09			51·03
Rietfontein	110	95	27	30·76	− ·25			30·51
Liebenberg Stroom	103	46	5	43·93	− ·10			43·83
Kaffir Kop	112	38	26	49·85	− ·31			49·54

Table A—*continued.*

JOHANNESBURG TO KROONSTAD—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	'	"	"			"
Doornkop	104	54	58	38·09	− ·49			37·60
Liebenberg Stroom	103	65	49	7·91	− ·09			7·82
Rietfontein	110	59	12	18·10	− ·30			17·80
Vleigenkraal..	101	32	16	26·52	+ ·44			26·96
Liebenberg Stroom	103	51	47	17·18	+ ·45			17·58
Doornkop	104	95	56	20·82	+ ·05			20·87
Boschrand	106	59	29	56·84	+ ·26			57·10
Doornkop	104	91	59	59·12	+ ·73			59·85
Rietfontein	110	28	30	5·04	+ ·32			5·36
Rhenosterkop II.	105	39	24	25·83	− ·54			25·29
Boschrand	106	55	6	7·05	+ ·26			7·31
Doornkop	104	85	29	29·23	− ·18			29·05
Vliegenkraal..	101	25	46	43·15	+ ·12			43·27
Doornkop	104	31	35	32·74	− ·11			32·63
Rhenosterkop II.	105	122	37	46·11	+ ·16			46·27
Braunzijn Kop	107	35	20	1·59	− ·27			1·32
Rhenosterkop II.	105	26	10	15·15	− ·10			15·05
Boschrand	106	118	29	45·96	− ·22			45·74
East end Kroonstad Base ..	109	101	45	20·19	+ ·12			20·31
Rhenosterkop II.	105	28	55	20·28	− ·37			19·91
Doornkop	101	49	19	20·49	+ ·09			20·58
East end Kroonstad Base ..	109	105	59	9·08	+ ·79			9·87
Doornkop	104	36	10	8·74	− ·27			8·47
Boschrand	106	37	50	41·73	+ ·41			42·14
East end Kroonstad Base ..	109	29	35	10·64	− ·40			10·24
Boschrand	106	135	45	11·28	− ·37			10·91
Braunzijn Kop	107	14	39	39·38	+ ·12			39·50
East end Kroonstad Base ..	109	33	7	45·12	− ·86			44·26
Boschrand	106	59	57	11·43	− ·31			11·12
West end Kroonstad Base ..	108	86	55	5·32	− ·01			5·31
East end Kroonstad ..	109	53	32	34·48	− ·46			34·02
Braunzijn Kop	107	31	22	39·48	− ·39			39·09
West end Kroonstad Base..	108	95	4	48·52	− ·09			48·43
East end Kroonstad Base ..	109	170	53	5·80	+ ·07			5·87
West end Kroonstad Base	108	3	49	6·23	− ·08			6·15
Doornkop	104	5	17	47·72	+ ·38			48·10
East end Kroonstad Base ..	109	122	40	20·09	− ·51			19·58
Braunzijn Kop	107	20	40	22·21	− ·39			21·82
Rhenosterkop II.	105	36	39	20·70	− ·27			20·43
East end Kroonstad Base ..	109	152	15	30·73	− ·91			29·82
Boschrand	106	17	15	25·32	− ·15			25·17
Rhenosterkop II.	105	10	29	5·55	− ·17			5·38
East end Kroonstad Base ..	109	69	7	45·61	− ·05			45·56
West end Kroonstad Base..	108	60	32	36·54	− ·27			36·27
Rhenosterkop II.	105	50	19	39·66	− ·43			39·23
West end Kroonstad Base..	108	56	43	30·31	− ·19			30·12
Rhenosterkop II.	105	79	14	59·94	− ·80			59·14
Doornkop	104	44	1	32·77	− ·29			32·48

Table A—*continued.*

JOHANNESBURG TO KROONSTAD—*continued.*

Name of Station.	Number	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″			″
West end Kroonstad Base	108	40	44	11·55	− ·09			11·46
Doornkop	104	41	27	56·46	+ ·11			56·57
Boschrand	106	97	47	53·16	+ ·10			53·26
West end Kroonstad Base	108	58	9	43·20	− ·08			43·12
Boschrand	106	75	47	59·85	− ·06			59·79
Braunzijn Kop	107	46	2	18·86	− ·27			18·59
West end Kroonstad Base	108	155	37	25·06	− ·36			24·70
Rhenosterkop II.	105	13	40	18·96	− ·16			18·80
Braunzijn Kop	107	10	42	17·27	·00			17·27
West end Kroonstad Base	108	97	27	41·86	− ·28			41·58
Rhenosterkop II.	105	39	50	34·11	− ·26			33·85
Boschraud	106	42	41	46·11	− ·16			45·95

KROONSTAD TO WEPENER.

Name of Station.	Number	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Mijnhardt's Rust	113	53	52	50·77	+ ·24	+ ·32		51·33
Rietfontein	110	98	18	31·79	+ ·24	+ ·14		32·17
Kaffir Kop	112	27	48	39·30	+ ·24	− ·46		39·08
Zwartkrans	114	46	10	37·57	− ·02	+ ·35		37·90
Mijnhardt's Rust	113	38	44	18·91	− ·02	− ·36		18·53
Kaffir Kop	112	95	5	9·43	− ·02	+ ·01		9·42
Rhebokberg	115	54	48	43·26	+ ·36	+ ·19		43·81
Mijnhardt's Rust	113	51	6	37·71	+ ·36	− ·15		37·92
Zwartkrans	114	74	4	49·75	+ ·37	− ·04		50·08
Machache	116	45	37	6·11	+ ·08	+ ·38		6·57
Rhebokberg	115	85	46	4·82	+ ·08	− ·27		4·63
Zwartkrans	114	48	37	1·07	+ ·09	− ·11		1·05
Mabula	117	74	34	4·34	+ ·01	− ·12		4·23
Rhebokberg	115	55	56	57·16	+ ·02	− ·21		56·97
Machache	116	49	29	6·88	+ ·02	+ ·38		7·28
Thaba Putsua	118	52	23	38·14	− ·24			37·90
Mabula	117	32	18	32·62	+ ·20			32·82
Machache	116	95	17	55·83	− ·15			55·68
Thaba Tsueu	119	38	16	5·52	− ·51			5·01
Machache	116	45	26	34·59	+ ·08			34·67
Thaba Putsua	118	96	17	25·30	− ·02			25·28
Mabula	117	37	39	5·54	− ·43			5·11
Thaba Putsua	118	43	53	47·16	+ ·22			47·38
Thaba Tsueu	119	98	27	14·64	− ·69			13·95
Machache	116	49	51	21·24	− ·23			21·01
Thaba Tsueu	119	60	11	9·12	− ·18			8·94
Mabula	117	69	57	38·16	− ·23			37·93
Jammersberg	120	75	19	49·28	− ·53			48·75
Mabula	117	47	43	6·69	+ ·01			6·70
Thaba Tsueu	119	56	57	9·16	+ ·13			9·29

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angle.
Kroonstad to Wepener—*continued.*								
		°	′	″	″			″
Gobo Gobo	121	68	19	51·05	+ ·23			51·28
Jammersberg	120	65	0	50·30	+ ·30			50·60
Thaba Tsueu	119	46	39	21·25	— ·07			21·18
Aasvogel Berg	127	42	21	59·37	+ ·53			59·90
Mabula	117	66	25	32·01	+ ·17			32·18
Thaba Putsua	118	71	12	47·08	+ ·21			47·29
Jammersberg	120	147	42	0·64	+ ·07			0·71
Mabula	117	18	56	40·22	— ·59			39·63
Aasvogel Berg*	127	13	21	23·83				23·83
Gobo Gobo	124	165	38	41·93	+ ·99			42·92
Jammersberg	120	7	21	21·06	+ ·30			21·36
Aasvogel Berg	127	6	59	56·31	+ ·10			56·41
Koesberg	126	102	28	34·74	— ·38			34·36
Jammersberg .. .	120	8	15	1·49	+ ·41			1·90
Aasvogel Berg .. .	127	69	16	25·29	— ·04			25·25
Gobo Gobo	124	16	30	52·91	+ ·33			53·24
Koesberg	126	87	12	45·90	+ ·01			45·91
Aasvogel Berg	127	76	16	21·60	+ ·06			21·66
Dikhoele	121	117	16	2·99	— ·15			2·84
Jammersberg	120	22	48	52·16	+ ·16			52·32
Thaba Tsueu..	119	39	55	5·93	+ ·12			6·05
Dikhoele	121	8	37	32·01	+ ·30			32·31
North end Wepener Base ..	122	59	2	38·04	— ·04			38·00
Jammersberg	120	112	19	50·17	— ·12			50·05
Dikhoele	121	42	16	31·90	+ ·15			32·05
North end Wepener Base ..	122	43	43	21·54	+ ·10			21·64
South end Wepener Base ..	123	94	0	6·64	+ ·89			7·53
Dikhoele	121	23	57	41·78	+ ·28			42·06
Gobo Gobo	124	76	46	11·65	+ ·44			12·09
South end Wepener Base ..	123	79	16	6·12	+ ·25			6·37
Dikhoele	121	167	52	11·32	— ·58			10·74
Thaba Tsueu..	119	6	44	15·32	— ·19			15·13
Gobo Gobo	124	5	23	34·75	— ·41			34·34
Dikhoele	121	74	51	45·69	+ ·73			46·42
Jammersberg	120	42	11	58·14	+ ·14			58·28
Gobo Gobo	124	62	56	16·30	+ ·64			16·94
Dikhoele	121	50	54	3·91	+ ·45			4·36
Jammersberg	120	47	38	59·87	— ·08			59·79
South end Wepener Base ..	123	81	26	57·09	+ ·07			57·16
Dikhoele	121	66	14	13·68	+ ·43			14·11
North end Wepener Base ..	122	41	42	17·28	+ ·22			17·50
Gobo Gobo	124	72	3	30·07	·00			30·07
South end Wepener Base ..	123	160	43	3·21	+ ·32			3·53
Jammersberg	120	5	27	1·78	— ·22			1·51
Gobo Gobo	124	13	49	55·35	— ·20			55·15
North end Wepener Base ..	122	2	1	4·26	— ·12			4·14
Gobo Gobo	124	4	42	41·58	+ ·44			42·02
South end Wepener Base ..	123	173	16	12·76	+1·14			13·90

* Derived, not observed.

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KROONSTAD TO WEPENER—*continued.*								
		°	′	″	″			″
Jammersberg	120	64	40	50·30	— ·04			50·26
South end Wepener Base	123	12	33	9·55	+ ·82			10·37
North end Wepener Base	122	102	45	59·58	+ ·06			59·64
Gobo Gobo	124	9	7	13·77	— ·64			13·13
North end Wepener Base	122	100	44	55·32	+ ·18			55·50
Jammersberg	120	70	7	52·03	— ·26			51·77
Koesberg	126	15	15	48·84	— ·39			48·45
Jammersberg	120	15	36	22·55	+ ·71			23·26
Gobo Gobo	124	149	7	49·02	+ ·66			49·68
Lemoenfontein	125	23	23	50·52	+ ·39			50·91
Gobo Gobo	124	94	35	5·92	+ ·61			6·53
Koesberg	126	62	1	8·64	+ ·06			8·70
Jammersberg	120	99	45	20·13	+ ·61			20·74
Gobo Gobo	124	54	32	43·10	+ ·05			43·15
Lemoenfontein	125	25	42	1·07	— ·06			1·01
Jammersberg	120	84	8	57·58	— ·10			57·48
Koesberg	126	46	45	19·80	+ ·45			20·25
Lemoenfontein	125	49	5	51·59	+ ·33			51·92
WEPENER TO CALA.								
		°	′	″	″	″		″
Nthodimonate	128	83	18	38·46	+ ·01	— ·25		38·22
Aasvogel Berg	127	54	45	7·19	+ ·01	+1·38		8·58
Thaba Putsua	118	42	1	29·63	+ ·02	—1·13		28·52
Helvelyn	129	88	18	30·41	+ ·15	+ ·64		31·20
Aasvogel Berg	127	46	35	58·91	+ ·14	+ ·38		59·43
Nthodimonate	128	45	5	36·76	+ ·14	—1·02		35·88
Bendearg	130	38	32	14·30	+ ·28	+ ·18		14·76
Helvelyn	129	61	2	20·13	+ ·29	+ ·13		20·55
Nthodimonate	128	80	25	33·97	+ ·28	— ·31		33·94
Waschbank Peak	131	87	42	54·37	— ·15	+ ·43		54·65
Helvelyn	129	40	38	18·01	— ·14	+ ·73		18·60
Bendearg	130	51	38	56·61	— ·14	—1·16		55·31
Xuka	10	80	59	55·78	+ ·37	— ·07		56·08
Waschbank Peak	131	22	58	25·15	+ ·37	+ ·10		25·62
Bendearg	130	76	1	40·70	+ ·36	— ·03		41·03
Lubisi	8	46	6	13·65	+ ·25	— ·03		13·87
Waschbank Peak	131	80	49	27·12	+ ·24	+ ·41		27·77
Xuka	10	53	4	26·02	+ ·24	— ·38		25·88
HOPETOWN TO WEPENER.								
		°	′	″	″	″		″
Orange River	134	61	38	42·76	+ ·18	— ·24		42·70
Besterskop	133	63	43	13·03	+ ·18	— ·43		12·78
Elandsberg II.	132	54	38	7·92	+ ·19	+ ·71		8·82
Wonderkloof	135	46	7	39·36	+ ·10	+ ·02		39·48
Besterskop	133	86	38	50·14	+ ·11	— ·38		49·87
Orange River	134	47	13	34·65	+ ·10	+ ·36		35·11

Table A—*continued.*

HOPETOWN TO WEPENER—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Boschjes Pan	136	89	2	46·05	− ·27	+ ·33		46·11
Wonderkloof	135	33	4	12·09	− ·28	− ·64		11·17
Orange River	134	57	53	6·58	− ·28	+ ·31		6·61
Platkop	137	53	20	41·76	+ ·06	+ ·36		42·18
Wonderkloof	135	51	42	53·25	+ ·07	− ·68		52·64
Boschjes Pan	136	74	56	30·51	+ ·06	+ ·32		30·89
Luiper's Rand	140	83	57	50·96	+ ·02	+ ·03		51·01
Wonderkloof	135	40	10	6·01	+ ·02	− ·08		5·95
Platkop	137	55	52	7·68	+ ·01	+ ·05		7·74
Fauresmith Hill	138	85	28	12·58	+ ·20			12·78
Luiper's Rand	140	53	4	33·49	+ ·31			33·80
Platkop	137	41	27	14·89	+ ·49			15·38
Lokshoek	139	29	31	49·38	+ ·21			49·59
Fauresmith Hill	138	125	46	15·10	− ·13			14·97
Platkop	137	24	41	57·24	− ·17			57·07
Drie Baden	141	31	49	37·92	+ ·33			38·25
Fauresmith Hill	138	100	17	21·17	+ ·26			21·43
Lokshoek	139	47	53	2·59	+ ·09			2·68
Luiper's Rand	140	87	35	46·99	− ·15			46·84
Fauresmith Hill	138	48	28	11·15	− ·33			10·82
Drie Baden	141	43	56	4·35	− ·26			4·09
De Put	142	43	27	18·22	− ·15	+ ·08		18·15
Drie Baden	141	84	30	20·92	− ·15	+ ·24		21·01
Lokshoek	139	52	2	28·06	− ·14	− ·32		27·60
Lemoenfontein	125	56	53	31·15	− ·01	− ·53		30·61
De Put	142	71	22	14·67	− ·01	+ ·24		14·90
Lokshoek	139	51	44	25·24	− ·01	+ ·29		25·52
Koesberg	126	42	57	31·58	+ ·09	+ ·01		31·68
De Put	142	59	28	7·70	+ ·09	+ ·86		8·65
Lemoenfontein	125	77	34	33·92	+ ·09	− ·87		33·14

HOPETOWN TO KIMBERLEY.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Loskop I.	143	72	6	59·00	− ·34	− ·03		58·63
Elandsberg II.	132	37	34	30·29	− ·25	+ ·14		30·18
Orange River	134	70	18	35·07	− ·57	− ·11		34·39
Joostenberg	144	125	33	39·44	− ·22	+ ·01		39·23
Elandsberg II.	132	30	13	11·61	− ·41	+ ·15		11·35
Loskop I.	143	23	53	10·80	+ ·09	− ·16		10·73
Leeuwberg	145	30	53	25·70	+ ·45	− ·20		25·95
Loskop I.	143	110	47	25·53	+ ·30	− ·02		25·81
Joostenberg	144	38	19	10·39	− ·11	+ ·22		10·50
Eckmond	146	88	6	27·50	− ·01	+ ·11		27·60
Loskop I.	143	63	33	19·65	− ·02	+ ·21		19·84
Leeuwberg	145	28	20	14·79	− ·66	− ·32		13·81

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
HOPETOWN TO KIMBERLEY—*continued.*								
		°	′	″	″	″		″
Orange River	134	28	54	4·91	+ ·07	+ ·05		5·03
Loskop I.	143	89	39	5·17	— ·19	+ ·01		4·99
Eckmond	146	61	26	51·56	— ·32	— ·06		51·18
Kolskop	147	40	32	35·34	— ·14	— ·13		35·07
Orange River	134	39	28	56·34	— ·24	+ .14		56·28
Eckmond	146	99	58	31·48	— ·05	— ·01		31·42
Leeuwberg	145	36	9	53·06	+ ·02	— ·15		52·93
Kolskop	147	33	21	59·54	— ·11	+ ·20		59·63
Eckmond	146	110	28	9·75	+ ·10	— ·05		9·80
Moller Pile	148	65	34	3·52	+ ·02	+ ·04		3·58
Kolskop	147	56	56	16·87	+ ·02	— ·44		16·45
Leeuwberg	145	57	29	44·84	+ ·02	+ ·40		45·26
Wolvedam	150	61	14	45·63	— ·25	— ·02		45·36
Kolskop	147	38	34	24·99	— ·26	— ·21		24·52
Moller Pile	148	80	10	54·55	— ·57	+ ·23		54·21
Scholtz Kop	149	42	42	54·87	·00	— ·29		54·58
Moller Pile	148	24	36	42·73	— ·47	+ ·24		42·50
Wolvedam	150	112	40	25·00	— ·45	+ ·05		24·60
Moller Pile	148	55	34	11·82	— ·10	— ·01		11·71
Scholtz Kop	149	64	0	57·90	+ ·01	— ·05		57·86
Kolskop	147	60	24	54·87	+ ·17	+ ·06		55·10
Wolvedam	150	57	13	24·61	+ ·04	— ·01		24·64
Scholtz Kop	149	45	4	6·74	+ ·08	+ ·21		7·03
Kimberley Hill	151	77	42	29·19	+ ·02	— ·20		29·01
Tarantal Kop	152	25	48	59·90	— ·20	— ·19		59·51
Kimberley Hill	151	121	51	19·24	— ·29	— ·02		18·93
Scholtz Kop	149	32	19	42·51	— ·30	+ ·21		42·42
Wolvedam	150	53	33	15·74	+ ·13	+ ·25		16·12
Kimberley Hill	151	85	32	26·09	+ ·07	+ .01		26·17
Distant Bush	154	40	54	18·62	+ ·07	— ·26		18·43
Distant Bush	154	82	47	5·59	+ ·05	— ·02		5·62
Kimberley Hill	151	33	22	38·98	+ ·06	+ ·18		39·22
Doornboom	153	63	50	14·93	+ ·94	— ·16		15·71
Kimberley Hill	151	12	39	4·97	+ ·20	+ ·08		5·25
Sand	155	140	25	38·93	— ·52	— ·04		38·37
Doornboom	153	26	55	16·52	+ ·07	— ·04		16·55
Doornboom	153	74	37	10·93	+ ·26	— ·08		11·11
Kimberley Hill	151	41	31	6·30	+ ·34	+ ·03		6·67
Tarantal Kop	152	63	51	42·77	+ ·17	+ ·05		42·99
Distant Bush	154	90	45	31·44	+1·01	— ·20		32·25
Sand	155	57	39	18·62	+ ·16	+ ·12		18·90
Doornboom	153	31	35	8·83	+ ·14	+ ·08		9·05
Distant Bush	154	51	11	56·77	— ·09	— ·11		56·57
Sand	155	82	46	20·31	— ·69	— ·16		19·46
Kimberley Hill	151	46	1	43·95	+ ·25	+ ·27		44·47
South end Kimberley Base..	161	74	3	50·60	— ·45	— ·07		50·08
Distant Bush	154	58	41	41·34	— ·25	+ ·20		41·29
Doornboom	153	47	14	28·66	+ ·31	— ·13		28·84

Table A—*continued.*

HOPETOWN TO KIMBERLEY—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Warwicker	156	41	2	22·81	− ·09	− ·01		22·71
Sand	155	62	10	37·20	+ ·39	+ ·02		37·61
Doornboom	153	76	46	58·86	+1·00	− ·01		59·85
Warwicker	156	38	15	26·11	+ ·96	+ ·05		27·12
Sand	155	30	6	18·92	− ·57	+ ·13		18·48
South end Kimberley Base..	161	111	38	14·50	+ ·18	− ·18		14·50
South end Kimberley Base..	161	44	12	0·48	+ ·22	− ·08		0·62
Sand	155	92	16	56·11	− ·18	+ ·16		56·09
Doornboom	153	43	31	2·79	+ ·70	− ·08		3·41
South end Kimberley Base	161	58	47	45·23	+ ·21	− ·03		45·41
Warwicker	156	49	5	53·64	+ ·92	+ ·12		54·68
North end Kimberley Base..	159	72	6	19·69	+ ·37	− ·09		19·97
South end Kimberley Base..	161	52	50	29·27	− ·03	− ·15		29·09
Sand	155	39	59	13·80	− ·30	+ ·23		13·73
North end Kimberley Base .	159	87	10	17·52	− ·20	− ·08		17·24
South end Kimberley Base..	161	67	26	14·02	− ·04	− ·11		13·87
Warwicker	156	79	17	48·91	+ ·86	+ ·05		49·82
Doornboom	153	33	15	56·07	+ ·81	+ ·06		56·44
Distant Bush..	154	52	24	45·39	+ ·14	− ·02		45·51
Longitude Point	157	79	0	50·43		+ ·68		51·11
Doornboom	153	48	34	22·96		+ ·62		23·58
Doornboom	153	42	11	8·48		+ ·19		8·67
Longitude Point	157	50	7	18·51		− ·57		17·94
Sand	155	87	41	33·08	+ ·16	+ ·26		33·50
South end Kimberley Base..	161	98	33	35·55	− ·39	+ ·26		35·42
Flag Point	160	30	20	58·56	+ ·03	+ ·16		58·75
Measured end	158	51	5	31·59	− ·33	− ·42		30·84
Measured end	158	51	46	4·89	+ ·55	− ·33		5·11
Flag Point	160	82	39	6·42	+ ·30	− ·12		6·60
Warwicker	156	45	34	46·98	+ ·89	+ ·45		48·32
South end Kimberley Base..	161	39	45	30·51	− ·49	− ·15		49·87
Flag Point	160	112	59	59·98	+ ·33	+ ·04		60·35
Warwicker	156	27	14	9·03	+ ·67	+ ·11		9·81
South end Kimberley Base..	161	58	47	45·03	+ ·11	+ ·41		45·55
Warwicker	156	18	20	37·96	+ ·22	+ ·34		38·52
Measured end	158	102	51	36·48	+ ·22	− ·75		35·95
Longitude Point	157	129	8	8·95		+ ·10		9·05
Distant Bush..	154	20	49	36·56		− ·10		36·46
Sand	155	30	2	14·46		+ ·14		14·60
Measured end	158	77	8	24·62	− ·15	− ·54		23·93
Warwicker	156	30	45	15·68	− ·02	+ ·47		16·13
North end Kimberley Base..	159	72	6	19·83	+ ·07	+ ·07		19·97
Measured end	158	68	3	6·67	·00	+ ·66		7·33
Well	160*a*	64	28	7·02	+ ·18	− ·30		6·90
South end Kimberley Base .	161	47	28	45·89	+ ·25	− ·36		45·78
Measured end	158	111	56	52·22	− ·07	+ ·64		52·79
North end Kimberley Base..	159	23	13	21·93	+ ·04	− ·25		21·72
Well	160*a*	44	49	45·70	+ ·19	− ·39		45·50

Table A—*continued.*

HOPETOWN TO KIMBERLEY—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″			″
Aasvogel Kop	162	72	20	40·67	− ·15			40·53
Scholtz Kop	149	21	41	51·26	+ ·03			51·29
Tarantal Kop	152	85	57	29·37	+ ·03			29·40
Paardeberg	163	63	14	57·15	+ ·19			57·34
Scholtz Kop	149	43	37	53·09	+ ·19			53·28
Aasvogel Kop	162	73	7	11·37	+ ·55			11·92
Rondefontein	164	49	32	49·42	− ·22			49·20
Paardeberg	163	64	29	12·90	− ·22			12·68
Aasvogel Kop	162	65	58	0·76	− ·41			0·35
Boshof Hill	165	75	9	2·21	+ ·18			2·39
Rondefontein	164	45	52	29·64	+ ·18			29·82
Aasvogel Kop	162	58	58	29·64	− ·01			29·63
Tarantal Kop	152	61	44	31·60	+ ·21			31·81
Boshof Hill	165	28	39	51·27	+ ·22			51·49
Aasvogel Kop	162	89	35	37·54	+ ·03			37·57
Spion Kop	166	65	16	21·48	+ ·46			21·94
Aasvogel Kop	162	50	3	58·61	+ ·42			59·03
Tarantal Kop	152	64	39	38·56	+ ·83			39·39
Spion Kop	166	82	59	25·98	+ ·02			26·00
Tarantal Kop	152	43	20	32·44	+ ·08			32·52
Kameelpan II.	167	53	40	2·11	− ·35			1·76
Spion Kop	166	101	54	40·12	− ·13			39·99
Kameelpan II.	167	51	14	55·66	− ·14			55·52
Boshof Hill	165	26	50	25·67	− ·77			24·90
Spion Kop	166	109	49	32·42	− ·35			32·07
Boshof Hill	165	30	38	50·70	− ·76			49·94
Aasvogel Kop	162	39	31	39·11	− ·57			38·54
Kameelpan II.	167	104	54	57·77	− ·49			57·28
Boshof Hill*	165	28	49	23·35				23·35
Tarantal Kop*	152	46	15	40·10				40·10
Spion Kop	166	175	5	53·90	+ ·11			54·01
Boshof Hill*	165	1	58	58·45				58·45
Tarantal Kop*	152	2	55	7·58				7·58

KIMBERLEY TO KROONSTAD.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Karreelaagte	168	55	30	16·74	+ ·12	− ·24		16·62
Rondefontein	164	74	22	50·61	+ ·13	+ ·05		50·79
Boshof Hill	165	50	6	54·32	+ ·12	+ ·19		54·63
Du Plessis Dam	169	57	3	31·02	− ·26	− ·17		30·59
Karreelaagte	168	75	18	12·52	− ·26	+ ·07		12·33
Boshof Hill	165	47	38	19·88	− ·26	+ ·10		19·72
Weltevreden	171	41	38	6·92	+ ·15	− ·23		6·84
Karreelaagte	168	45	12	34·71	+ ·16	+ ·29		35·16
Du Plessis Dam	169	93	9	20·47	+ ·15	− ·06		20·56

* Derived, not observed.

Table A—*continued*.

KIMBERLEY TO KROONSTAD—*continued*.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Bosberg	170	55	7	32·88	+ ·07	− ·02		32·88
Karreelaagte	168	44	0	26·60	+ ·07	− ·07		26·60
Weltevreden	171	80	52	4·91	+ ·06	+ ·09		5·06
Biesie Pan	172	78	27	2·80	− ·18	− ·11		2·56
Bosberg	170	54	37	0·02	− ·14	+ ·30		0·18
Weltevreden	171	46	55	59·95	− ·13	− ·19		59·63
Schoongezicht	173	52	46	56·70	− ·01	+ ·15		56·84
Bosberg	170	53	0	46·93	− ·01	− ·08		46·84
Biesie Pan	172	74	12	18·48	·00	− ·07		18·41
Zootvlei	175	32	56	32·49	+ ·01			32·50
Schoongezicht	173	62	7	19·92	− ·30			19·62
Biesie Pan	172	84	56	11·71	− ·30			11·41
Therons Kop	174	42	13	8·71	+ ·10			8·81
Biesie Pan	172	70	56	58·67	+ ·02			58·69
Zoetvlei	175	66	49	59·83	+ ·12			59·95
Schoongezicht	173	92	58	43·94	− ·22			43·72
Zoetvlei	175	33	53	27·34	+ ·11			27·45
Therons Kop	174	53	7	54·01	− ·09			53·92
Biesie Pan	172	13	59	13·04	− ·32			12·72
Therons Kop	174	10	54	45·30	− ·19			45·11
Schoongezicht	173	155	6	3·86	− ·52			3·34
Braunzijn Kop	107	74	40	52·00	+ ·31	− ·01		52·30
Therons Kop	174	54	25	2·66	+ ·31	− ·06		2·91
Zoetvlei	175	50	54	11·86	+ ·31	+ ·07		12·24
Nooitverwacht	176	72	11	25·71	− ·28	+ ·05		25·48
Braunzijn	107	48	50	37·39	− ·28	+ ·02		37·13
Zoetvlei	175	58	58	3·23	− ·28	− ·07		2·88
Rhenosterkop II.	105	58	50	44·41	− ·21	− ·30		43·90
Braunzijn Kop	107	67	52	20·14	− ·21	+ ·93		20·86
Nooitverwacht	176	58	17	2·48	− ·21	− ·63		1·64

KROONSTAD TO NEWCASTLE.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Langberg II.	177	44	40	15·73	− ·21	+ ·27		15·79
Kaffir Kop	112	90	13	2·46	− ·20	− ·06		2·20
Elandskop II.	111	45	6	49·51	− ·21	− ·21		49·09
Vierfontein	178	87	47	58·51	+ ·02	+ ·09		58·62
Langberg II.	177	38	1	12·16	+ ·02	·00		12·18
Elandskop II.	111	54	10	56·38	+ ·02	− ·09		56·31
Vaalbank Kop	179	64	34	29·27	+ ·27	+ ·11		29·65
Langberg II.	177	49	42	6·77	+ ·26	− ·27		6·76
Vierfontein	178	65	43	30·37	+ ·27	+ ·16		30·80
Kaalkop	180	71	27	43·62	+ ·04	+ ·08		43·74
Vaalbank Kop	179	62	8	28·19	+ ·04	+ ·13		28·36
Vierfontein	178	46	28	57·57	+ ·05	− ·21		57·41

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KROONSTAD TO NEWCASTLE—*continued.*								
		°	′	″	″	″		″
Hermitage	181	66	5	27·00	+ ·08	+ ·15		27·23
Vaalbank Kop	179	52	40	45·05	+ ·09	− ·17		44·97
Kaalkop	180	61	13	50·68	+ ·08	+ ·02		50·78
Gemsbokberg	182	54	44	46·24	− ·13	+ ·11		46·22
Hermitage	181	71	42	30·09	− ·13	+ ·10		30·06
Kaalkop	180	53	32	46·82	− ·13	− ·21		46·48
Drakensberg	58	42	4	1·95	+ ·20	+ ·35		2·50
Hermitage	181	92	6	56·03	+ ·21	+ ·09		56·33
Gemsbokberg	182	45	49	4·48	+ ·20	− ·44		4·24
Inkwelo	59	79	6	46·27	+ ·16	− ·03		46·40
Drakensberg	58	52	15	2·16	+ ·16	+ ·26		2·58
Gemsbokberg	182	48	38	14·94	+ ·17	− ·23		14·88
KIMBERLEY TO OTTOSHOOP.								
		°	′	″	″	″		″
Zwartkop II	183	82	28	51·03	− ·03	− ·20		50·80
Boshof Hill	165	79	49	28·81	− ·02	− ·18		28·61
Kameelpan II	167	17	41	40·59	− ·03	+ ·38		40·94
Boesmanskop	184	60	43	35·81	− ·21	+ ·13		35·73
Zwartkop II	183	56	39	42·19	− ·21	− ·33		41·65
Kameelpan II	167	62	36	43·60	− ·22	+ ·20		43·58
Uitkyk	185	46	55	41·82	− ·51	− ·17		41·14
Zwartkop II	183	62	16	29·56	− ·51	− ·14		28·91
Boesmanskop	184	70	47	51·49	− ·51	+ ·31		51·29
Leeuwlaagte	186	101	16	13·09	− ·09	+ ·12		13·12
Uitkyk	185	28	25	2·37	− ·09	− ·27		2·01
Boesmanskop	184	50	18	45·45	− ·09	+ ·15		45·51
Winterhoek	187	83	1	12·20	+ ·06	+ ·10		12·36
Uitkyk	185	57	23	13·93	+ ·05	− ·27		13·71
Leeuwlaagte	186	39	35	34·28	+ ·05	+ ·17		34·50
Boomplaats	188	41	37	14·87	+ ·13	− ·13		14·87
Uitkyk	185	57	21	16·40	+ ·13	− ·07		16·46
Winterhoek	187	81	1	28·89	+ ·13	+ ·20		29·22
Houtnek	189	39	27	28·22	+ ·28	− ·13		28·37
Boomplaats	188	101	53	45·25	+ ·28	− ·10		45·43
Winterhoek	187	38	38	46·37	+ ·27	+ ·23		46·87
Bethel Pella	190	91	40	55·67	− ·29	+ ·04		55·42
Houtnek	189	36	36	41·35	− ·29	− ·10		40·96
Winterhoek	187	51	42	24·63	− ·29	+ ·06		24·40
Schoonheid	191	51	37	29·34	− ·28	+ ·02		29·08
Houtnek	189	50	41	35·52	− ·28	− ·06		35·18
Bethel Pella	190	77	40	56·98	− ·29	+ ·04		56·73
Langvallei	192	97	45	7·20	− ·26	− ·05		6·89
Houtnek	189	47	16	9·23	− ·25	− ·06		8·92
Schoonheid	191	34	58	45·02	− ·26	+ ·11	..	44·87

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KIMBERLEY TO OTTOSHOOP—*continued.*								
		°	′	″	″	″	″	″
Never Mind	193	68	33	20·37	+ ·09	— ·02		20·44
Langvallei	192	55	11	1·68	— ·13	— ·03		1·52
Schoonheid	191	61	15	38·52	+ ·17	+ ·05		38·74
Kopje Enkel	194	52	8	12·81	— ·01	+ ·02		12·82
Never Mind	193	100	45	56·15	— ·16	+ ·01		56·00
Schoonheid	191	27	5	52·31	— ·68	— ·03		51·60
Kameelpan I.	195	69	18	53·38	+ ·54	+ ·01		53·93
Never Mind	193	60	31	9·32	+ ·50	— ·02		9·80
Kopje Enkel	191	49	39	56·19	+ ·24	+ ·01		56·44
Langvallei	192	13	16	37·37	+ ·98		— ·04	38·31
Never Mind	193	135	9	31·16	— ·43		+ ·08	33·76
Kameelpan I.	195	31	33	48·62	— ·14		+ ·01	48·19
Smitskraal	196	31	56	8·56	+ ·82	+ ·03		9·41
Kameelpan I.	195	62	25	40·65	+ ·09	— ·02		40·72
Kopje Enkel	194	85	38	9·83	+ ·40	— ·01		10·22
Nooitgedacht II.	197	51	29	4·21	— ·08		— ·02	4·11
Kopje Enkel	194	28	27	57·40	+ ·04		— ·04	57·40
Smitskraal	196	100	2	58·31	+ ·47	+ ·06		58·84
Kameelpan I.	195	32	11	41·29	— ·16	— ·05		41·08
Smitskraal	196	68	6	49·75	— ·35	+ ·03		49·43
Nooitgedacht II.	197	79	41	27·87	—1·02	+ ·02		26·87
Kopje Enkel	194	57	10	12·43	+ ·36		+ ·03	12·82
Nooitgedacht II.	197	28	12	23·66	— ·94		+ ·04	22·76
Kameelpan I.	195	94	37	24·94	— ·07	— ·07		24·80
Amsterdam	198	84	22	54·12	+ ·13	— ·02		54·23
Nooitgedacht II.	197	24	53	17·43	+ ·14	+ ·07		17·64
Smitskraal	196	70	43	48·13	+ ·14	— ·05		48·22
Klipkuil	199	19	5	28·13	+ ·01	+ ·08		28·22
Nooitgedacht II.	197	60	29	28·51	+ ·26	— ·07		28·70
Amsterdam	198	100	25	8·35	+ ·26	— ·01		8·60
Doornhoek	200	62	31	17·11	— ·21		— ·05	16·85
Amsterdam	198	63	0	57·09	+ ·01		+ ·01	57·11
Klipkuil	199	54	27	47·34	— ·19	+ ·04		47·19
Nooitgedacht II.	197	61	51	11·29	+ ·03	·00		11·32
Klipkuil	199	35	22	19·21	— ·20	— ·04		18·97
Doornhoek	200	82	46	30·76	— ·17	+ ·04		30·63
Amsterdam	198	37	24	11·26	+ ·25		— ·02	11·49
Doornhoek	200	20	15	13·65	+ ·04		+ ·09	13·78
Nooitgedacht II.	197	122	20	34·80	+ ·29	— ·07		35·02
Morgenzon	202	48	55	46·16	— ·22	— ·21		45·73
Doornhoek	200	66	59	34·45	— ·22	+ ·26		34·49
Klipkuil	199	64	4	41·59	— ·21	— ·05		41·33
Holpan	201	93	38	12·60	— ·39	+ ·10		12·31
Doornhoek	200	40	30	53·52	— ·38	+ ·12		53·26
Morgenzon	202	45	50	55·99	— ·39	— ·22		55·38
Panfontein	203	74	21	20·30	+ ·37	+ ·09		20·76
Holpan	201	87	43	45·17	+ ·37	+ ·10		45·64
Morgenzon	202	17	54	53·68	+ ·38	— ·19		53·87

Table A—*continued.*

KIMBERLEY TO OTTOSHOOP—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″	″	″
Makouwskop	204	41	13	11·60	− ·37	+ ·08		11·31
Panfontein	203	94	56	27·62	− ·38	+ ·09		27·33
Morgenzon	202	43	50	22·86	− ·37	− ·17		22·32
Stroppan	205	68	50	8·16	+ ·18	− ·18		8·16
Makouwskop	204	65	33	31·91	+ ·18	+ ·40		32·49
Morgenzon	202	45	36	25·85	+ ·18	− ·22		25·81
Doornbult III.	206	91	21	28·64	− ·46	+ ·13		28·31
Makouwskop	204	57	9	42·00	− ·46	+ ·08		41·62
Stroppan	205	31	28	51·27	− ·45	− ·21		50·61
Rosalie	207	109	34	51·02	− ·18	+ ·10		50·94
Doornbult III.	206	64	45	22·52	− ·17	+ ·09		22·44
Stroppan	205	5	39	47·06	− ·17	− ·19		46·70
Rietpan	208	80	58	36·44	+ ·21	− ·18		36·47
Rosalie	207	39	47	22·86	+ ·22	+ ·42		23·50
Stroppan	205	59	14	0·51	+ ·21	− ·24		0·48
Doornbult II.	209	51	23	22·08	+ ·01	− ·18		21·91
Rosalie	207	54	52	41·32	+ ·02	+ ·35		41·69
Rietpan	208	73	43	57·22	+ ·01	− ·22		57·01
Simonsvlei	210	97	34	0·35	+ ·34	+ ·18		0·87
Rosalie	207	54	11	44·95	+ ·33	+ ·09		45·37
Doornbult II.	209	28	14	14·05	+ ·33	− ·27		14·11
Zwarts Rust	211	58	5	17·14	+ ·30	+ ·29		17·73
Simonsvlei	210	75	53	25·32	+ ·29	+ ·17		25·78
Doornbult II.	209	46	1	17·16	+ ·29	− ·46		16·99
Boschpan	212	84	56	6·94	+ ·02	− ·25		6·71
Zwarts Rust	211	39	22	35·72	+ ·02	+ ·59		36·33
Doornbult II.	209	55	41	17·69	+ ·03	− ·34		17·38
Karreekuil	213	43	53	46·39	+ ·15	+ ·40		46·94
Zwarts Rust	211	79	28	5·78	+ ·15	+ ·20		6·13
Boschpan	212	56	38	8·04	+ ·14	− ·60		7·58
Disselboom Pan	214	51	12	58·22	+ ·38	− ·18		58·42
Karreekuil	213	61	16	56·10	+ ·38	+ ·55		57·03
Boschpan	212	67	30	5·68	+ ·39	− ·37		5·70
Driekuil	215	88	7	45·05	+ ·60	+ ·28		45·93
Karreekuil	213	65	20	30·97	+ ·60	+ ·17		31·74
Disselboom Pan	214	26	31	42·80	+ ·61	− ·45		42·96
Middelbult	216	48	26	4·91	− ·16	− ·62		4·13
Driekuil	215	43	18	40·77	− ·16	+ ·76		41·37
Disselboom Pan	214	88	15	15·99	− ·17	− ·14		15·68
Makoies Pan	217	38	34	26·14	+ ·07	− ·37		25·84
Middelbult	216	77	6	34·92	+ ·66	+ ·40		35·98
Disselboom Pan	214	64	18	58·97	+ ·76	− ·03		59·70
Doornbult I.	218	64	8	40·99	− ·48		+ ·46	40·97
Disselboom Pan	214	37	55	5·02	+ ·33		+ ·28	5·63
Makoies Pan	217	77	56	16·14	− ·24	− ·74		15·16
Middelbult	216	47	31	30·93	− ·09	+ ·26		31·10
Makoies Pan	217	39	21	50·00	− ·31	− ·37		49·32
Doornbult I.	218	93	6	40·83	− ·30	+ ·11		40·64

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
KIMBERLEY TO OTTOSHOOP—*continued.*								
		°	′	″	″	″	″	″
Disselboom Pan	214	26	23	53·95	+ ·43		− ·31	54·07
Doornbult I.	218	28	57	59·84	+ ·18		− ·35	59·67
Middelbult	216	124	38	5·85	+ ·57	+ ·66		7·08
Bethlehem	219	60	54	55·61	+ ·13	− ·41		55·33
Doornbult I.	218	45	9	23·54	+ ·12	+ ·56		24·22
Makoies Pan	217	73	55	41·44	+ ·12	− ·15		41·41
De Paarl	220	56	31	12·76	+ ·10	− ·48		12·38
Doornbult I.	218	19	51	26·40	+ ·10	+ ·81		27·31
Bethlehem	219	103	37	21·13	+ ·10	− ·33		20·90
Houthaal Boomen	221	85	22	5·65	− ·16	+ ·11		5·60
Doornbult I.	218	27	4	29·16	− ·82	+ ·41		28·75
De Paarl	220	67	33	26·60	+ ·42	− ·52		26·50
Welvediend	223	20	34	5·64	+1·83	− ·27		7·20
Houthaal Boomen	221	134	43	11·27	+ ·08	− ·03		11·32
De Paarl	220	24	42	42·23	− ·68	+ ·30		41·85
Sypherpan	222	32	27	58·61	+1·46		+ ·98	1·05
Houthaal Boomen	221	79	46	21·22	+ ·28		− ·27	21·23
Welvediend	223	67	45	39·00	+ ·44		− ·71	38·73
Doornbult I.	218	60	26	26·62	+ ·66		+ ·39	27·67
Houthaal Boomen	221	60	8	21·87	− ·20		+ ·18	21·85
Sypherpan	222	59	25	12·52	+ ·06		− ·58	12·00
Malopo's Oog	224	67	35	17·51	− ·04	+ ·11		17·58
Welvediend	223	62	29	5·49	− ·04	+ ·38		5·83
De Paarl	220	49	55	38·38	− ·03	− ·49		37·86
Polfontein	225	86	28	57·45	+ ·05	− ·26		57·24
Malopo's Oog	224	24	5	35·68	+ ·05	+ ·40		36·13
De Paarl	220	69	25	27·32	+ ·05	− ·14		27·23
Grootfontein	226	104	43	22·27	+ ·39	− ·18		22·48
Malopo's Oog	224	25	30	12·94	+ ·38	+ ·21		13·53
Polfontein	225	49	46	24·11	+ ·38	− ·03		24·46
Klippan	227	43	9	12·13	+ ·95	− ·26		12·82
Malopo's Oog	224	67	55	26·02	+ ·17	+ ·34		26·53
Grootfontein	226	68	55	20·55	+1·28	− ·08		21·75
Witkop I.	92	64	19	12·64	+ ·75		+ ·39	13·78
Grootfontein	226	43	47	58·50	+ ·15		+ ·22	58·87
Klippan	227	71	52	48·30	+ ·82	− ·61		48·51
Malopo's Oog	224	47	54	23·26	+ ·69	+ ·21		24·16
Klippan	227	28	43	36·17	− ·13	− ·35		35·69
Witkop I.	92	103	21	59·98	+ ·62	+ ·14		60·74
Grootfontein	226	25	7	22·05	+1·13		− ·30	22·88
Witkop I.	92	39	2	47·34	− ·13		− ·25	46·96
Malopo's Oog	224	115	49	49·28	+ ·86	+ ·55		50·69
Vergenoeg	93	56	14	49·35	− ·48	− ·41		48·46
Witkop I.	92	63	2	28·12	− ·49	+ ·53		28·16
Klippan	227	60	42	44·87	− ·49	− ·12		44·26

Table A—*continued.*

TIE-CHAIN THROUGH KLERKSDORP TO KROONSTAD.

Name of Station.	Number.	Observed Angles.			Figural.	Circuit.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Leeuwfontein	228	65	30	40·56	+ ·15	− ·30		40·41
Driekuil	215	64	53	28·34	+ ·16	+ ·71		29·21
Middelbult	216	49	35	52·38	+ ·15	− ·41		52·12
Schietfontein	229	68	51	7·82	+ ·19	+ ·28		8·29
Driekuil	215	53	9	13·48	+ ·18	− ·34		13·32
Leeuwfontein	228	57	59	39·32	+ ·18	+ ·06		39·56
Rhenosterberg Hoek ..	230	53	33	57·52	− ·38	− ·13		57·01
Schietfontein	229	66	22	56·32	− ·38	+ ·93		56·87
Leeuwfontein	228	60	3	8·47	− ·38	− ·80		7·29
Doornplaats	231	56	49	58·12	− ·20	+ ·60		58·52
Schietfontein	229	47	41	53·80	− ·19	− ·21		53·40
Rhenosterberg Hoek ..	230	75	28	9·84	− ·20	− ·39		9·25
Klerksdorp	232	45	34	11·30	+ ·20	+ ·19		11·69
Doornplaats	231	51	18	43·99	+ ·20	+ ·23		44·42
Rhenosterberg Hoek ..	230	83	7	5·26	+ ·21	− ·42		5·05
Vlaklaagte	233	57	26	25·49	− ·13	+ ·64		26·00
Doornplaats	231	80	39	57·96	− ·13	+ ·14		57·97
Klerksdorp	232	41	53	38·56	− ·13	− ·78		37·65
Paradijs	234	67	37	30·65	+ ·43	− ·13		30·95
Vlaklaagte	233	43	18	34·75	+ ·42	+ ·76		35·93
Klerksdorp	232	69	3	55·28	+ ·43	− ·63		55·08
Bovenlands Plaats	235	69	46	47·87	− ·42	− ·15		47·30
Vlaklaagte	233	60	43	29·24	− ·42	+1·09		29·91
Paradijs	234	49	29	46·20	− ·42	− ·94		44·84
Nooitverwacht	176	45	16	24·68	+ ·46	+1·17		26·31
Vlaklaagte	233	62	30	53·64	+ ·47	+ ·01		54·12
Bovenlands Plaats	235	72	12	42·55	+ ·46	−1·18		41·83
Rhenosterkop II.	105	33	17	30·10	− ·13	+ ·53		30·50
Nooitverwacht	176	36	17	48·37	− ·13	− ·24		48·00
Bovenlands Plaats	235	110	24	44·92	− ·14	− ·29		44·49

BELFAST TO LIMPOPO.

Name of Station.	Number.	Observed Angles.			Figural.	Base.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Mount Anderson	236	69	36	39·25	− ·44	− ·23		38·58
Tafelkop (D.K.)	70	48	51	52·60	− ·44	+ ·55		52·71
Verloren Vlei	71	61	31	40·51	− ·45	− ·32		39·74
Thama Koosh	237	53	3	54·35	− ·40	− ·47		53·48
Mount Anderson	236	59	53	13·14	− ·40	+ ·21		12·95
Verloren Vlei	71	67	3	3·76	− ·40	+ ·26		3·62
Manoutsa	238	61	47	52·14	+ ·27	− ·34		52·07
Mount Anderson	236	58	29	29·15	+ ·27	+ ·38		29·80
Thama Koosh	237	59	42	49·09	+ ·26	− ·04		49·31

Table A—*continued.*

BELFAST TO LIMPOPO—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Base.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″	″		″
Iron Crown	239	48	43	13·29	− ·08	− ·55		12·66
Manoutsa	238	60	20	22·41	− ·08	+ ·36		22·69
Thama Koosh	237	70	56	38·22	− ·07	+ ·19		38·34
Portugal	240	51	55	52·56	− ·07	− ·49		52·00
Iron Crown	239	82	9	28·86	− ·07	− ·12		28·67
Thama Koosh	237	45	54	58·92	− ·06	+ ·61		59·47
Schnell's Kop	241	58	57	29·39	− ·22	− ·38		28·79
Iron Crown	239	106	5	16·79	− ·21	− ·18		16·40
Portugal	240	14	57	18·49	− ·21	+ ·56		18·84
Matala	242	59	33	9·22	+ ·06	− ·37		8·91
Schnell's Kop	241	31	3	35·13	+ ·06	+ ·36		35·55
Portugal	240	89	23	25·96	+ ·06	+ ·01		26·03
Loskop II.	243	106	39	56·90	− ·21			56·69
Schnell's Kop	241	27	41	30·77	+ ·06			30·83
Matala	242	45	38	40·64	+ ·02			40·66
Loskop II.	243	59	29	12·37	− ·29			12·08
Kameelkop	244	106	14	6·88	− ·26			6·62
Matala	242	14	16	42·08	+ ·50			42·58
Loskop II.	243	31	9	59·99	+ ·29			60·28
Matala	242	65	11	27·67	− ·47			27·20
South end Houts River Base	245	83	38	35·14	·00			35·14
Loskop II.	243	106	32	10·06	− ·46			9·60
Kameelkop	244	30	55	26·37	− ·09			26·28
North end Houts River Base	246	42	32	24·85	− ·46			24·39
Loskop II.	243	90	39	12·36	·00			12·36
Kameelkop	244	73	41	11·96	+ ·03			11·99
South end Houts River Base	245	15	39	37·05	− ·10			36·95
Loskop II.	243	47	2	57·69	− ·17			57·52
Matala	242	9	21	38·45	− ·50			37·95
North end Houts River Base	246	123	35	25·86	·54			25·32
Loskop II.	243	15	52	57·70	− ·46			57·24
South end Houts River Base	245	4	12	43·07	+ ·43			43·50
North end Houts River Base	246	159	54	20·22	− ·69			19·53
Kameelkop	244	32	32	54·92	− ·29			54·63
Matala	242	79	28	9·70	+ ·03			9·73
South end Houts River Base	245	67	58	58·09	+ ·10			58·19
Kameelkop	244	75	18	40·51	− ·17			40·34
Matala	242	23	38	20·48	·00			20·48
North end Houts River Base	246	81	3	1·01	− ·08			0·93
Kameelkop	244	42	45	45·59	+ ·12			45·71
South end Houts River Base	245	19	52	20·12	+ ·33			20·45
North end Houts River Base	246	117	21	55·37	− ·23			55·14
Matala	242	55	49	49·22	+ ·03			49·25
North end Houts River Base	246	36	18	54·36	− ·15			54·21
South end Houts River Base	245	87	51	18·21	+ ·43			18·64
Blaauwberg	247	36	6	28·23	+ ·20			28·43
Loskop II.	243	96	57	37·96	+ ·19			38·15
Matala	242	46	56	0·00	+ ·24			0·24

Table A—*continued.*

BELFAST TO LIMPOPO—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Base.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″			″
Lejuma	248	72	28	39·48	+ ·28			39·66
Loskop II.	248	48	29	7·66	+ ·20			7·86
Blaauwberg	247	59	2	17·98	+ ·24			18·22
Schnell's Kop	241	29	25	25·56	− ·17			25·39
Loskop II.	243	107	53	17·48	− ·18			17·30
Lejuma	248	42	41	26·50	− ·13			26·37
Dwarsberg	249	28	4	31·38	− ·04			31·34
Lejuma	248	28	7	33·06	− ·38			32·68
Blaauwberg	247	123	48	0·77	− ·11			0·36
Pont	250	29	8	36·41	+ ·33			36·74
Blaauwberg	247	51	28	33·70	− ·04			33·66
Dwarsberg	249	99	22	57·68	+ ·29			57·97
Lejuma	248	50	38	52·12	·00			52·12
Dwarsberg	249	71	18	26·30	+ ·33			26·63
Pont	250	58	2	55·09	+ ·32			55·41
Blaauwberg	247	72	19	27·07	− ·37			26·70
Pont	250	28	54	18·68	− ·01			18·67
Lejuma	248	78	46	25·18	− ·38			24·80
Dogola	251	72	30	26·23	− ·20			26·03
Lejuma	248	35	11	37·08	− ·21			36·87
Pont	250	72	18	9·07	− ·20			8·87

SECONDARY CHAIN, PRETORIA TO JOHANNESBURG.
Measured with 8-inch and 6-inch Theodolites.
(Angles measured with the 8-inch Theodolite are distinguished by an asterisk.)

Name of Station.	Number.	Observed Angles.			Figural.	Base.	Non-Circuit.	Seconds of Corrected Angles.
		°	′	″	″			″
Meintjes Kop	254	43	37	50·58	−1·15			49·43
Daspoort	252	35	26	12·15	− ·21			11·94
Cable Hill	84	100	55	59·24	− ·46			58·78
Muckleneuk*	258	48	37	24·31	+ ·98			25·29
Cable Hill	84	21	0	9·61				9·61
Meintjes Kop*	254	110	22	24·31	+ ·85			25·16
Daspoort	252	16	15	25·22	+1·31			26·53
Meintjes Kop	254	66	44	34·34	+1·39			35·73
Muckleneuk	253	96	59	54·85	+2·99			57·84
Cable Hill	84	79	55	49·63	− ·46			49·17
Muckleneuk	258	48	22	30·54	+2·01			32·55
Daspoort	252	51	41	37·37	+1·10			38·47
Koedoespoort*	255	26	1	15·58	+4·31			19·89
Muckleneuk*	253	82	47	39·01	−3·05			35·96
Meintjes Kop*	254	121	11	1·94	+2·24			4·18
Camp*	256	58	25	54·70	+1·65			56·35
Meintjes Kop*	254	54	46	47·64	−1·86			45·78
Koedoespoort*	255	66	47	14·13	+3·78			17·91

Table A—*continued.*

Name of Station.	Number.	Observed Angles.			Figural.	Base.	Non-Circuit.	Seconds of Corrected Angles.
SECONDARY CHAIN, PRETORIA TO JOHANNESBURG—*continued.*								
		°	′	″	″			″
Muckleneuk*	253	36	15	57·74	+ ·81			58·55
Koedoespoort*	255	40	45	58·55	— ·53			58·02
Camp*	256	102	58	2·52	+ ·96			3·48
Meintjes Kop*	254	66	24	14·30	+4·10			18·40
Camp*	256	44	32	7·82	— ·69			7·13
Muckleneuk*	253	69	8	36·75	—2·24			34·51
Klapper Kop	257	41	44	57·53	+ ·47			58·00
Daspoort	252	57	5	38·41	+ ·48			38·89
Cable Hill	84	81	9	22·87	+ ·47			23·34
Zwartkop III.	258	75	15	51·17	— ·04			51·13
Daspoort	252	46	59	24·14	— ·04			24·10
Klapper Kop	257	57	44	45·06	— ·03			45·03
Irene	259	48	30	16·86	+ ·85			17·71
Zwartkop III.	258	56	1	18·72	+ ·85			19·57
Klapper Kop	257	75	28	22·12	+ ·84			22·96
Brakfontein	260	71	34	39·97	— ·77			39·20
Zwartkop III.	258	47	24	34·80	— ·78			34·02
Irene	259	61	0	47·81	— ·77			47·04
Oliphantsfontein	261	63	11	11·20	— ·36			10·84
Brakfontein	260	64	2	6·74	— ·36			6·38
Irene	250	52	46	43·31	— ·35			42·96
Klipfontein	262	34	28	46·70	— ·57			46·13
Brakfontein	260	59	37	15·82	— ·57			15·25
Oliphantsfontein	261	85	53	59·46	— ·56			58·90
Witpoort	263	75	5	43·22	— ·58			42·64
Brakfontein	260	62	25	5·61	— ·59			5·02
Klipfontein	262	42	29	13·27	— ·58			12·69
Driefontein	264	65	47	0·46	+ ·37			0·83
Whitpoort	268	71	31	4·30	+ ·37			4·67
Klipfontein	262	42	41	54·47	+ ·37			54·84
Germiston	265	49	1	30·08	+ ·35			30·43
Driefontein	264	50	34	41·84	— ·13			41·71
Klipfontein	262	80	23	48·53	— ·15			48·38
Observatory Hill (Johannesburg)	96	56	54	25·78	+ ·55			26·33
Klipfontein	262	23	36	18·37	— ·33			18·04
Germiston	265	99	29	15·30	+ ·58			15·88
Driefontein	264	20	45	56·19	+ ·85			57·04
Germiston	265	50	27	45·22	+ ·23			45·45
Observatory Hill (Johannesburg)	96	108	46	17·10	+ ·66			17·76
Klipfontein	262	56	47	30·16	+ ·18			30·34
Observatory Hill (Johannesburg)	96	51	51	51·32	+ ·11			51·43
Driefontein	264	71	20	38·03	+ ·72			38·75
P6 Beacon	266	39	0	7·30	—1·14			6·16
Observatory Hill (Johannesburg)	96	36	18	31·80	— ·30			31·50
Germiston	265	104	41	23·89	—1·44			22·45

Table A—*concluded.*

Name of Station.	Number.	Observed Angles.			Figural.	Base.	Non-Circuit.	Seconds of Corrected Angles.
SECONDARY CHAIN, PRETORIA TO JOHANNESBURG—*continued.*								
		°	′	″	″			″
Klipriviersberg	267	33	42	20·93	+ ·66			21·59
Germiston	265	50	19	53·27	−1·10			52·17
P6 Beacon	266	95	57	46·83	− ·44			46·39
Observatory Hill (Johannesburg)	96	52	57	53·94	+1·46			55·40
P6 Beacon	266	56	57	39·53	+ ·70			40·23
Klipriviersberg	267	70	4	22·41	+2·17			24·58
Germiston	265	54	21	30·62	− ·34			30·28
Klipriviersberg	267	36	22	1·48	+1·51			2·99
Observatory Hill (Johannesburg)	96	89	16	25·74	+1·16			26·90

Table B.

TRIANGULAR ERRORS.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
KING WILLIAM'S TOWN TO NEWCASTLE.								
	″	″		″	″		″	″
3	+0·50	+0·51	8	−0·25	+0·44	14	+1·13	−2·53
1	+0·51		6	−0·29		13	+0·70	
2	−1·52		7	+0·10		12	+0·70	
5	+0.71	−1·34	9	−0·20	+0·03	14	−0·56	+1·33
2	−0·08		8	+0·06		11	−0·93	
3	+0·71		7	+0·11		13	+0·16	
4	−1·07	+1·52	10	+0·49	−1·25	18	+1·06	+3·13
2	−0·86		8	−1·08		12	−0·66	
3	+0·41		9	−0·32		13	−1·41	
4	−1·06	+2·57	11	−0·46	+0·10	19	+0·42	−0·72
2	−0·78		10	+0·01		12	+0·11	
5	−0·73		9	+0·35		18	+0·19	
4	0·00	−0·28	12	−0·14	−0·48	19	−0·01	+1·25
3	+0·31		10	+0·79		13	−0·69	
5	−0·03		11	−0·17		12	−0·55	
6	−0·10	−0·17	13	+0·86	+0·29	19	+0·44	+1·14
2	−0·29		12	+0·09		18	−0·87	
4	+0·56		11	−1·24		13	−0·71	
7	+0·88	−1·65	14	−0·57	+1·50	12	+0·04	+0·14
6	−0·26		12	−0·62		18	−0·77	
4	+1·03		11	−0·31		14	+0·59	

Table B—*continued.*

King William's Town to Newcastle—*continued.*

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
18	−0·29	+0·46	26	−0·02	+1·04	33	+0·99	−1·92
14	+0·54		22	−0·65		37	−0·04	
13	−0·71		25	−0·37		34	+0·97	
11	−0·91	+1·88	26	−0·58	+1·24	35	+0·67	−0·78
14	−0·38		22	−0·20		33	+0·28	
15	−0·54		27	−0·46		34	−0·17	
14	−0·19	+0·59	27	−0·48	+1·48	35	−0·15	−0·35
15	−0·23		22	−0·85		37	+1·26	
13	−0·17		25	−0·15		33	−0·76	
11	+0·02	+1·08	26	−0·60	+0·80	37	−0·30	0·00
13	−0·33		25	−0·22		33	+0·33	
15	−0·77		27	+0·02		36	−0·03	
16	−0·12	+0·15	28	+0·66	−2·00	37	−0·27	+0·63
14	−0·24		22	+0·67		34	+0·10	
15	+0·21		27	+0·67		36	−0·46	
17	−0·17	−1·25	29	−0·07	+0·22	35	−0·82	−1·54
14	+0·64		27	−0·07		37	+1·22	
15	+0·78		26	−0·08		34	+1·14	
16	−0·20	−0·45	25	−0·07	+0·37	40	+0·28	−0·26
15	+0·57		24	+0·15		34	−0·01	
17	+0·08		30	−0·45		36	−0·01	
16	−0·32	+0·95	24	+1·43	−2·05	36	+0·60	−1·36
14	−0·88		30	+0·17		40	+0·74	
17	+0.25		31	+0·45		38	+0·02	
20	−0·04	−1·53	30	+0·19	+0·06	38	−0·71	+0·87
19	+0·71		31	+0·38		40	−0·40	
18	+0·86		32	−0·63		39	+0·24	
21	−0·22	+0·01	32	+0·07	+0·08	34	−1·28	+2·25
20	−0·14		31	−0·48		40	−0·61	
19	+0·85		34	+0·88		39	−0·41	
21	+0·33	−0·35	33	−0·50	−0·39	36	+0·59	+1·10
20	−0·01		32	−0·11		34	−1·26	
22	−0·67		31	+1·00		38	−0·43	
24	+0·25	−1·05	32	+0·19	−0·30	38	−0·25	+0·39
21	+0·54		34	−0·04		34	+0·03	
22	+0·26		38	+0·15		39	−0·17	
23	−1·66	+2·70	31	+1·48	−0·72	36	+0·83	+0·90
21	−1·11		33	−0·34		34	−1·24	
24	+0·07		34	−0·42		39	+0·01	
23	−0·78	+1·66	35	+1·07	−0·62	38	−0·68	+0·60
21	−0·58		33	+0·11		36	+0·27	
22	−0·30		31	−0·56		39	−0·19	
23	−0·88	−0·01	31	+0·92	−2·08	40	+0·38	−1·09
22	+0·56		35	+1·75		39	+0·43	
24	+0·83		34	−0·59		36	+0·33	
22	+0·26	−0·09	38	+0·66	−1·80	38	−0·45	+2·71
25	−0·63		34	+1·08		40	−1·01	
24	+0·46		36	−0·44		34	−1·25	

Table B—*continued.*

KING WILLIAM'S TOWN TO NEWCASTLE—*continued.*

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
39	+0·35		43	−0·16		53	−0·11	
40	−0·57	+0·03	44	−0·22	+0·67	52	−0·34	+0·79
42	+0·19		46	−0·29		51	−0·34	
40	+0·51		45	−0·34		54	−0·38	
39	−0·69	−0·06	46	+0·16	+0·36	53	−0·14	+1·10
41	+0·24		48	−0·18		52	−0·58	
39	−0·34		45	−0·20		55	−0·30	
41	+0·37	+0·30	46	+0·40	−0·38	54	−0·68	+1·59
42	−0·33		47	+0·18		53	−0·61	
40	−0·06		45	−0·54		56	+1·27	
41	−0·13	−0·32	47	−0·17	+1·07	55	+1·48	−3·75
42	+0·51		48	−0·36		54	+1·00	
41	−0·24		46	+0·55		57	−0.24	
42	−0·94	+2·39	47	+0·35	−1·08	55	+0.03	+0·13
44	−1·21		48	+0·18		56	+0.08	
41	+0·04		47	−0·17		58	+0·06	
42	−0·04	+0·07	48	−0·79	+1·81	55	+0·05	−0·05
43	−0·07		50	−0·85		57	−0·06	
41	−0·20		47	−0·15		56	−0·16	
43	+0·26	+0·46	48	+0·05	+0·14	55	+0·08	−0·33
44	−0·52		49	−0·04		58	+0·41	
42	−0·98		48	−0·74		57	−0·30	
43	−0·34	+2·01	50	−0·45	+1·45	56	+0·24	+0·41
44	−0·69		49	−0·26		58	−0·35	
44	−0·53		47	−0·31		59	+0·04	
43	−0·80	+2·58	50	−0·41	+0·50	57	+0·03	+0·38
45	−1·25		49	+0·22		58	−0·45	
44	−0·75		51	+0·57		58A	−0·01	
45	−0·59	+1·38	35	+0·40	−1·11	58	−0·01	+0·03
46	−0·04		37	+0·14		59	−0·01	
43	−0·96		52	+0·46				
45	−0·66	+1·86	51	+0·57	−1·35			
46	−0·24		37	+0·32				

Probable error of a single angle ± 0·49″

NEWCASTLE TO BELFAST.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
60	−0·08		60	+0·10		64	−0·55	
59	+0·15	−0·60	62	+0·51	−0·98	63	+0·30	+0·06
57	+0·53		61	+0·37		61	+0·19	
61	+0·30		59	+0·03		66	−0·07	
59	+0·23	−0·42	60	−0·01	−0·03	63	+0·29	−0·29
60	−0·11		62	+0·01		64	+0·07	
62	+0·50		63	−0·69		65	−0·48	
61	+0·67	−1·37	61	−0·36	+1·00	63	−0·01	+0·58
59	+0·20		62	+0·05		66	−0·09	

Table B—*continued.*

NEWCASTLE TO BELFAST—*continued.*

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
62	−0·42		79	−0·53		79	+0·10	
63	+0·11	+0·43	71	−0·47	+0·96	75	+1·28	−0·74
65	−0·12		73	+0·04		71	−0·64	
67	+0·09		71	−0·69		75	+0·44	
66	+0·16	+0·16	74	−0·45	+1·33	73	+0·28	−1·98
64	−0·41		79	−0·19		74	+1·26	
69	+0·21		74	+0·43		79	−0·63	
66	+0·24	−0·49	73	+0·07	−0·27	75	−0·53	+1·33
67	+0·04		71	−0·23		73	−0·17	
68	+0·03		73	+0·11		78	−0·18	
66	−0·15	+0·21	79	−0·34	−0·65	76	−0·35	−0·02
69	−0·09		74	+0·88		75	+0·55	
65	−0·15		75	−0·09		77	−0·46	
66	−0·09	+0·57	74	+0·38	0·00	76	+0·39	+0·49
68	−0·33		79	−0·29		75	−0·42	
72	+0·06		75	+0·75		75	+0·13	
69	+0·26	−0·63	73	−0·21	−0·37	78	−0·43	+0·12
67	+0·31		71	−0·17		77	+0·18	
70	+0·19		75	−1·19		76	+0·04	
68	−0·05	−0·13	71	−0·06	+2·08	78	+0·25	+0·35
69	−0·01		74	−0·83		77	−0·64	
71	−0·10		76	−0·05		81	+0·94	
70	−0·25	+0·52	74	−0·02	+0·12	79	+0·34	−1·62
69	−0·17		71	−0·05		73	+0·34	
72	−0·73		71	−0·11		80	−0·03	
71	−0·88	+2·26	76	−0·06	+0·79	79	−0·16	+0·66
69	−0·65		75	−0·62		81	−0·47	
73	−0·62		74	−0·85		71	+0·41	
71	+0·87	+0·69	75	−0·57	+1·41	79	+0·35	−0·96
72	−0·94		76	+0·01		80	+0·20	

Probable error of a single angle ± 0 36″.

BELFAST TO OTTOSHOOP.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
82	−0·29		86	−0·73		90	+0·08	
80	+0·52	+0·85	85	−0·42	+0·87	89	+0·07	−0·39
81	−1·08		84	+0·28		88	+0·24	
83	−1·39		87	−0·26		91	−0·13	
82	+0·21	+0·53	85	+0·48	−0·02	89	−0·19	+0·39
81	+0·65		86	−0·20		90	−0·07	
84	−0·29		88	−0·47		87	−0·01	
83	−0·22	−0·12	87	−0·89	+0·72	89	+0·02	−0·26
81	+0·63		86	+0·64		91	+0·25	
85	−0·44		89	+0·10		92	+0·45	
83	+0·16	−0·40	87	+0·42	−0·41	91	−0·29	−0·30
84	+0·68		88	−0·11		90	+0·14	

Table B—*continued.*

BELFAST TO OTTOSHOOP—*continued.*

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
93	+0·16		95	+0·28		92	−0·75	
90	+0·01	−0·38	93	−0·34	+0·44	94	−0·58	+2·36
92	+0·21		92	−0·38		93	−1·03	
91	+0·23		94	+0·20				
92	−0·24	+0·16	92	+0·37	−1·42			
93	−0·15		95	+0·85				
90	+0·13		93	−0·69				
93	−0·31	+0·24	95	+0·57	+0·50			
91	−0·06		94	−0·38				

Probable error of a single angle ± 0·30″.

JOHANNESBURG TO KROONSTAD.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
96	+0·05		104	−0·49		109	+0·07	
86	+0·40	−0·59	103	−0·09	+0·38	108	−0·08	−0·37
84	+0·14		110	−0·30		104	+0·38	
97	−0·40		101	+0·44		109	−0·51	
86	−0·09	+0·98	103	+0·45	−0·94	107	−0·39	+1·17
96	−0·49		104	+0·05		105	−0·27	
98	+0·21		106	+0·26		109	−0·91	
97	+0·09	−0·61	104	+0·73	−1·31	106	−0·15	+1·23
96	+0·31		110	+0·32		105	−0·17	
99	+0·12		105	−0·54		109	−0·05	
98	−0·02	−0·45	106	+0·26	+0·46	108	−0·27	+0·75
97	+0·35		104	−0·18		105	−0·48	
100	+0·11		101	+0·12		108	−0·19	
99	−0·35	−0·23	104	−0·11	−0·17	105	−0·80	+1·28
98	+0·47		105	+0·16		104	−0·29	
101	−0·03		107	−0·27		108	−0·09	
99	+0·27	−1·03	105	−0·10	+0·59	104	+0·11	−0·12
100	+0·79		106	−0·22		106	+0·10	
102	+0·31		109	+0·12		108	−0·08	
101	−0·41	−0·31	105	−0·37	+0·16	106	−0·06	+0·41
100	+0·41		104	+0·09		107	−0·27	
103	−0·60		109	+0·79		108	−0·36	
101	−0·25	+0·97	104	−0·27	−0·93	105	−0·16	+0·52
102	−0·12		106	+0·41		107	0·00	
111	+0·16		109	−0·40		108	−0·28	
103	+0·28	−0·55	106	−0·37	+0·65	105	−0·26	+0·70
102	+0·11		107	+0·12		106	−0·16	
112	−0·02		109	−0·86				
103	+0·06	+0·05	106	−0·31	+1·18			
111	−0·09		108	−0·01				
110	−0·25		109	−0·46				
103	−0·10	+0·66	107	−0·39	+0·94			
112	−0·31		108	−0·09				

Probable error of a single angle ± 0·30″.

Table B—*continued.*

KROONSTAD TO WEPENER.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
113	+0·56		127	+0·53		121	+0·45	
110	+0·38	−0·72	117	+0·17	−0·91	120	−0·08	−0·44
112	−0·22		118	+0·21		123	+0·07	
114	+0·33		120	+0·07		121	+0·43	
113	−0·38	+0·06	117	−0·59		122	+0·22	−0·65
112	−0·01		127			124	0·00	
115	+0·55		124	+0·99		123	+0·32	
113	+0·21	−1·09	120	+0·30	−1·39	120	−0·22	+0·10
114	+0·33		127*	+0·10		121	−0·20	
116	+0·46		126	−0·38		122	−0·12	
115	−0·19	−0·25	120	+0·41	+0·01	124	+0·44	−1·46
114	−0·02		127	−0·04		123	+1·14	
117	−0·11		124	+0·33		120	−0·04	
115	−0·19	−0·05	126	+0·01	−0·40	123	+0·82	−0·84
116	+0·35		127	+0·06		122	+0·06	
118	−0·24		121	−0·15		124	−0·64	
117	+0·20	+0·19	120	+0·16	−0·13	122	+0·18	+0·72
116	−0·15		119	+0·12		120	−0·26	
119	−0·51		121	+0·30		126	−0·39	
116	+0·08	+0·45	122	−0·04	−0·14	120	+0·71	−0·98
118	−0·02		120	−0·12		124	+0·66	
117	−0·43		121	+0·15		125	+0·39	
118	+0·22	+0·90	122	+0·10	−1·14	124	+0·61	−1·06
119	−0·69		123	+0·89		126	+0·06	
116	−0·23		121	+0·28		120	+0·61	
119	−0·18	+0·64	124	+0·44	−0·97	124	+0·05	−0·60
117	−0·23		123	+0·25		125	−0·06	
120	−0·53		121	−0·58		120	−0·10	
117	+0·01	+0·39	119	−0·19	+1·18	126	+0·45	−0·68
119	+0·13		124	−0·41		125	+0·33	
124	+0·23		121	+0·73				
120	+0·30	−0·46	120	+0·14	−1·51			
119	−0·07		124	+0·64				

Probable error of a single angle ± 0·36″

WEPENER TO CALA.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
128	−0·24		130	+0·46		10	+0·30	
127	+1·39	−0·04	129	+0·42	−0·85	131	+0·47	−1·10
118	−1·11		128	−0·03		130	+0·33	
129	+0·79		131	+0.28		8	+0·22	
127	+0·52	−0·43	129	+0·59	+0·43	131	+0·65	−0·73
128	−0·88		130	−1·30		10	−0·14	

Probable error of a single angle ± 0·27″.

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* *See* note page 73.

Table B—*continued.*

HOPETOWN TO WEPENER.

Station.	Correction to Observed Angle. ″	Error of Triangle. ″	Station.	Correction to Observed Angle. ″	Error of Triangle. ″	Station.	Correction to Observed Angle. ″	Error of Triangle. ″
134	−0·06	−0·54*	140	+0·05	−0·05	140	−0·15	+0·74
133	−0·30		135	−0·06		138	−0·33	
132	+0·90		137	+0·06		141	−0·26	
135	+0·12	−0·31	138	+0·20	−1·00	142	−0·07	+0·44
133	−0·27		140	+0.31		141	+0·09	
134	+0·46		137	+0·49		139	−0·46	
136	+0·06	+0·83	139	+0·21	+0·09	125	−0·54	+0·03
135	−0·92		138	−0·13		142	+0·23	
134	+0·03		137	−0·17		139	+0·28	
137	+0·42	−0·19	141	+0·33	−0·68	126	+0·10	−0·27
135	−0·61		138	+0·26		142	+0·95	
136	+0·38		139	+0·09		125	−0·78	

Probable error of a single angle ± 0·21″.

* A triangle in survey of Cape Colony.

HOPETOWN TO KIMBERLEY.

Station.	Correction to Observed Angle. ″	Error of Triangle. ″	Station.	Correction to Observed Angle. ″	Error of Triangle. ″	Station.	Correction to Observed Angle. ″	Error of Triangle. ″
143	−0·37	+1·16	149	−0·29	+0·92	154	−0·20	+0·53
132	−0·11		148	−0·23		155	−0·85	
134	−0.68		150	−0·40		151	+0·52	
144	−0·21	+0·54	148	−0·11	−0·08	161	−0·52	+0·39
132	−0·26		149	−0·04		154	−0·05	
143	−0·07		147	+0·23		153	+0·18	
145	+0·25	−0·64	150	+0·03	−0·14	156	−0·10	−1·30
143	+0·28		149	+0·29		155	+0·41	
144	+0·11		151	−0·18		153	+0·99	
146	+0·10	+0·69	152	−0·39	+0·79	156	+1·01	−0·57
143	+0·19		151	−0·31		155	−0·44	
145	−0·98		149	−0·09		161	0·00	
134	+0·12	+0·44	150	+0·38	−0·27	161	+0·14	−0·74
143	−0·18		151	+0·08		155	−0·02	
146	−0·38		154	−0·19		153	+0·62	
147	−0·27	+0·43	154	+0·03	−1·05	161	+0·18	−1·50
134	−0·10		151	+0·24		156	+1·04	
146	−0·06		153	+0·78		159	+0·28	
145	−0.13	−0·01	151	+0·28	+0·25	161	−0·18	+0·53
147	+0·09		155	−0·56		155	−0·07	
146	+0·05		153	+0·03		159	−0·28	
148	+0·06	−0·06	153	+0·18	−0·77	161	−0·15	−1·13
147	−0·42		151	+0·37		156	+0·91	
145	+0·42		152	+0·22		153	+0·37	
150	−0·27	+1·08	154	+0·81	−1·31	154	+0·12	−1·42
147	−0·47		155	+0·28		157	+0·68	
148	−0·34		153	+0·22		153	+0·62	

Table B—*continued.*

Hopetown to Kimberley—*continued.*

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
153	+0·19		158	+0·66		166	+0·46	
157	−0·57	−0·04	160A	−0·12	−0·43	162	+0·42	−1·71†
155	+0·42		161	−0·11		152	+0·83	
161	−0·13		158	+0·57		166	+0·02	
160	+0·19	+0·69	159	−0·21	−0·16	152	+0·08	+0·25†
158	−0·75		160A	−0·20		167	−0·85	
158	+0·22		162	−0·15		166	−0·13	
160	+0·18	−1·74	149	+0·03	+0·09*	167	−0·14	+1·04†
156	+1·34		152	+0·03		165	−0·77	
161	−0·64		163	+0·19		166	−0·35	
160	+0·37	−0·51	149	+0·19	−0·93*	165	−0·76	+1·68†
156	+0·78		162	+0·55		162	−0·57	
161	+0·52		164	−0·22		167	−0·49†	
156	+0·56	−0·55	163	−0·22	+0·85*	165		
158	−0·53		162	−0·41		152		
157	+0·10		165	+0·18		166	+0·11†	
154	−0·10	−0·14	164	+0·18	−0·35*	165		
155	+0·14		162	−0·01		152		
158	−0·69		152	+0·21				
156	+0·45	+0·10	165	+0·22	−0·46*			
159	+0·14		162	+0·03				

Probable error of a single angle ± 0·32″

* Measured by Capt. Gordon. † Measured by Capt Ley.

All other triangles in this chain belong to Cape Colony Survey.

Kimberley to Kroonstad.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
168	−0·12		173	+0·14		107	+0·30	
164	+0·18	−0·37	170	−0·09	+0·02	174	+0·25	−0·93
165	+0·31		172	−0·07		175	+0·38	
169	−0·43		175	+0·01		176	−0·23	
168	−0·19	+0·78	173	−0·30	+0·59	107	−0·26	+0·84
165	−0·16		172	−0·30		175	−0·35	
171	−0·08		174	+0·10		105	−0·51	
168	+0·45	−0·46	172	+0·02	−0·24	107	+0·72	+0·68
169	+0·09		175	+0·12		176	−0·84	
170	+0·05		173	−0·22				
168	0·00	−0·20	175	+0·11	+0·20			
171	+0·15		174	−0·09				
172	−0·24		172	−0·32				
170	+0·16	+0·40	174	−0·19	+1·03			
171	−0·32		173	−0·52				

Probable error of a single angle ± 0·23″

Table B—*continued.*

KROONSTAD TO NEWCASTLE.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
177	+0·06		180	+0·12		58	+0·55	
112	−0·26	+0·62	179	+0·17	−0·13	181	+0·30	−0·61
111	−0·42		178	−0·16		182	−0·24	
178	+0·11		181	+0·23		59	+0·13	
177	+0·02	−0·06	179	−0·08	−0·25	58	+0·42	−0·49
111	−0·07		180	+0·10		182	−0·06	
179	+0·38		182	−0·02				
177	−0·01	−0·80	181	−0·03	+0·39			
178	+0·43		180	−0·34				

Probable error of a single angle ± 0·20″

KIMBERLEY TO OTTOSHOOP.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
183	−0·28		194	+0·01		198	+0·23	
165	−0·20	+0·08	193	−0·15	+0·85	200	+0·13	−0·58
167	+0·35		191	−0·71		197	+0·22	
184	−0·34		195	+0·55		202	−0·43	
183	−0·54	+0·90	193	+0·48	−1·28	200	+0·04	+0·65
167	−0·02		194	+0·25		199	−0·26	
185	−0·68		192	+0·94	−0·11	201	−0·29	
183	−0·65	+1·53	193	−0·40		200	−0·26	+1·16
184	−0·20		195	−0·43		202	−0·61	
186	+0·03		196	+0·85	−1·31	203	+0·46	
185	−0·36	+0·27	195	+0·07		201	+0·47	−1·12
184	+0·06		194	+0·39		202	+0.19	
187	+0·16		197	−0·10	−0·43	204	−0·29	
185	−0·22	−0·16	194	0·00		203	−0·29	+1·12
186	+0·22		196	+0·58		202	−0·54	
188	0·00		195	−0·21	+1·58	205	0·00	
185	+0·06	−0·39	196	−0·32		204	+0·58	−0·54
187	+0·33		197	−1·00		202	−0·04	
189	+0·15		194	+0·39	+0·65	206	−0·33	
188	+0·18	−0·83	197	−0·90		204	−0·38	+1·37
187	+0·50		195	−0·14		205	−0·66	
190	−0·25		198	+0·11	−0·41	207	−0·08	
189	−0·39	+0·87	197	+0·21		206	−0·08	+0·52
187	−0·23		196	+0·09		205	−0·36	
191	−0·26		199	+0·09	−0·53	208	+0·08	
189	−0·34	+0·85	197	+0·19		207	+0·64	−0·64
190	−0·25		198	+0·25		205	−0·03	
192	−0·31		200	−0·26	+0·39	209	−0·12	
189	−0·31	+0·77	198	+0·02		207	+0·37	−0·04
191	−0·15		199	−0·15		208	−0·21	
193	+0·07		197	+0·03		210	+0·52	
192	−0·16	−0·13	199	−0·24	+0·34	207	+0·42	−1·00
191	+0·22		200	−0·18		209	+0·06	

Table B—*continued.*

KIMBERLEY TO OTTOSHOOP—*continued.*

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
211	+0·59		216	+0·17		224	+0·07	
210	+0·46	−0·88	217	−0·68	+0·70	223	+0·34	+0·11
209	−0·17		218	−0·19		220	−0·52	
212	−0·23		214	+0·12		225	−0·21	
211	+0·61	−0·07	218	−0·17	−1·18	224	+0·45	−0·15
209	−0·31		216	+1·23		220	−0·09	
213	+0·55		219	−0·28		226	+0·21	
211	+0·35	−0·44	218	+0·68	−0·37	224	+0·59	−1·15
212	−0·46		217	−0·03		225	+0·35	
214	+0·20		220	−0·38		227	+0·69	
213	+0·93	−1·15	218	+0·91	−0·30	224	+0·51	−2·40
212	+0·02		219	−0·23		226	+1·20	
215	+0·88		221	−0·05		92	+1·14	
213	+0·77	−1·81	218	−0·41	+0·56	226	+0·37	−1·72
214	+0·16		220	−0·10		227	+0·21	
216	−0·78		223	+1·56		224	+0·90	
215	+0·60	+0·49	221	+0·05	−1·23	227	−0·48	−1·18
214	−0·31		220	−0·38		92	+0·76	
217	−0·30		222	+2·44		226	+0·83	
216	+1·06	−1·49	221	+0·01	−2·18	92	−0·38	−1·86
214	+0·73		223	−0·27		224	+1·41	
218	−0·02		218	+1·05		93	−0·89	
214	+0·61	+0·39	221	−0·02	−0·51	92	+0·04	+1·46
217	−0·98		222	−0·52		227	−0·61	

Probable error of a single angle ± 0·39″.

TIE-CHAIN THROUGH KLERKSDORP TO KROONSTAD.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
228	−0·15		232	+0·39		176	+1·63	
215	+0·87	−0·46	231	+0·43	−0·61	233	+0·48	−1·39
216	−0·26		230	−0·21		235	−0·72	
229	+0·47		233	+0·51		105	+0·40	
215	−0·16	−0·55	231	+0·01	+0·39	176	−0·37	+0·40
228	+0·24		232	−0·91		235	−0·43	
230	−0·51		234	+0·30				
229	+0·55	+1·14	233	+1·18	−1·28			
228	−1·18		232	−0·20				
231	+0·40		235	−0·57				
229	−0·40	+0·59	233	+0·67	+1·26			
230	−0·59		234	−1·36				

Probable error of a single angle ± 0·35″.

Table B—*continued.*

BELFAST TO LIMPOPO.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
236	−0·67	+1·33	243	+0·29	+0·18	247	+0·20	−0·63
70	+0·11		242	−0·47		243	+0·19	
71	−0·77		245	0·00		242	+0·24	
237	−0·87	+1·20	243	−0·46	+1·01	248	+0·23	−0·67
236	−0·19		244	−0·09		243	+0·20	
71	−0·14		246	−0·46		247	+0·24	
238	−0·07	−0·80	243	0·00	+0·07	241	−0·17	+0·48
236	+0·65		244	+0·03		243	−0·18	
237	+0·22		245	−0·10		248	−0·13	
239	−0·63	+0·23	243	−0·17	+1·21	249	−0·04	+0·83
238	+0·28		242	−0·50		248	−0·38	
237	+0·12		246	−0·54		247	−0·41	
240	−0·56	+0·20	243	−0·46	+0·72	250	+0·33	−0·58
239	−0·19		245	+0·43		247	−0·04	
237	+0·55		246	−0·69		249	+0·29	
241	−0·60	+0·64	244	−0·29	+0·16	248	0·00	−0·65
239	−0·39		242	+0·03		249	+0·33	
240	+0·35		245	+0·10		250	+0·32	
242	−0·31	−0·18	244	−0·17	+0·25	247	−0·37	+0·76
241	+0·42		242	0·00		250	−0·01	
240	+0·07		246	−0·08		248	−0·38	
243	−0·21	+0·13	244	+0·12	−0·22	251	−0·20	+0·61
241	+0·06		245	+0·33		248	−0·21	
242	+0·02		246	−0·23		250	−0·20	
243	−0·29	+0·05	242	+0·03	−0·31			
244	−0·26		246	−0·15				
242	+0·50		245	+0·43				

Probable error of a single angle ± 0·25″.

SECONDARY CHAIN PRETORIA TO JOHANNESBURG.

Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
	″	″		″	″		″	″
254	−1·15	+1·82	256	+1·65	−3·57	259	+0·85	−2·54
252	−0·21		254	−1·86		258	+0·85	
84	−0·46		255	+3·78		257	+0·84	
253	+0·98	−1·83	253	+0·81	−1·24	260	−0·77	+2·32
84			255	−0·53		258	−0·78	
254	+0·85		256	+0·96		259	−0·77	
252	+1·31	−5·69	254	+4·10	+1·17	261	−0·36	+1·07
254	+1·39		256	−0·69		260	−0·36	
253	+2·99		253	−2·24		259	−0·35	
84	−0·46	−2·65	257	+0·47	−1·42	262	−0·57	+1·70
253	+2·01		252	+0·48		260	−0·57	
252	+1·10		84	+0·47		261	−0·56	
255	+4·31	−3·50	258	−0·04	+0·11	263	−0·58	+1·75
253	−3·05		252	−0·04		260	−0·59	
254	+2·24		257	−0·03		262	−0·58	

Table B—*concluded.*

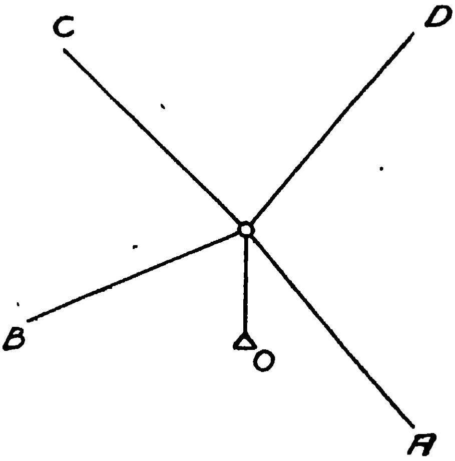
Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.	Station.	Correction to Observed Angle.	Error of Triangle.
SECONDARY CHAIN, PRETORIA TO JOHANNESBURG—*continued.*								
	″	″		″	″		″	″
264	+0·37		264	+0·85		267	+0·66	
263	+0·37	−1·11	265	+0·23	−1·74	265	−1·10	+0·88
262	+0·37		96	+0·66		266	−0·44	
265	+0·35		262	+0·18		96	+1·46	
264	−0·13	−0·07	96	+0·11	−1·01	266	+0·70	−4·33
262	−0·15		264	+0·72		267	+2·17	
96	+0·55		266	−1·14		265	−0·34	
262	−0·33	−0·80	96	−0·30	+2·88	267	+1·51	−2·33
265	+0·58		265	−1·44		96	+1·16	

Probable error of a single angle ± 0·92″

CORRECTIONS TO CENTRE.

OBSERVATORY HILL (JOHANNESBURG). No. 96.

Instrument eccentrically placed.



O … Beacon.
A … Paardekop II.
B … Blijvooruitzicht.
C … Nooitgedacht I.
D … Cable Hill.

Data.

d = 4·33 feet.

	°	′	Log. Distances.
Bearing to Beacon =	0	0	—
„ B =	67	41	5·3825
„ C =	125	25	5·3310
„ D =	188	53	5·2593
„ A =	343	8	5·1181

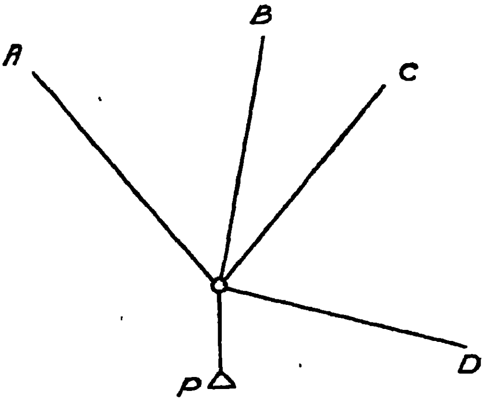
Resulting Corrections.

Bearing to B = + 3·42″.
„ C = + 3·52.
Bearing to D = − 0·76″.
„ A = − 1·97.

CORRECTIONS TO CENTRE—*continued.*

PAARDEKOP II. No. 98.

Instrument eccentrically placed.



P ... Beacon.
A ... Elandskop I.
B ... Witkop II.
C ... Blijvooruitzicht.
D ... Johannesburg.

Data.

$d = 0{\cdot}09$ feet.

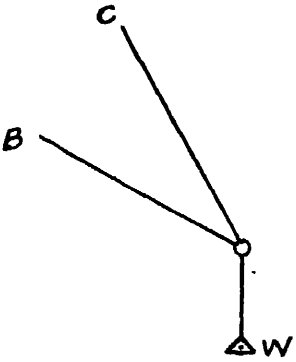
		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ A	=	135	0	5·391
„ B	=	189	0	5·400
„ C	=	221	0	5·421
„ D	=	286	0	5·118

Resulting Corrections.

″ ″
Bearing to A = + 0·05. Bearing to C = − 0·05.
„ B = − 0·01. „ D = − 0·14.

WASCHBANK PEAK. No. 131.

Instrument eccentrically placed for four arcs of the angle between B and C.



B ... Bendearg. C ... Xuka. W ... Beacon.

Data.

$d = 37{\cdot}328$ feet.

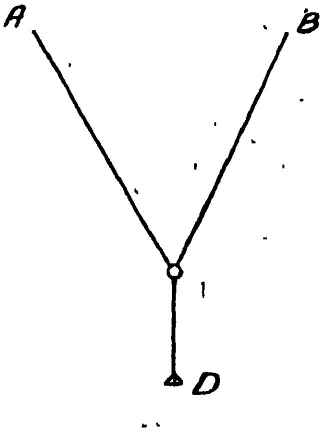
		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ B	=	121	56	5·2393
„ C	=	144	54	5·2316

Resulting Corrections.

Bearing to B = + 37″·66. Bearing to C = + 25″·97.

TAFEL KOP (D.K.). No. 70.

Instrument eccentrically placed for four arcs of the angle between A and B.



D ... Beacon. A ... Verloren Vlei.
B ... Mt. Anderson.

Data.

$d = 5{\cdot}93$ feet.

		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ A	=	151	42	5·4098
„ B	=	200	34	5·3819

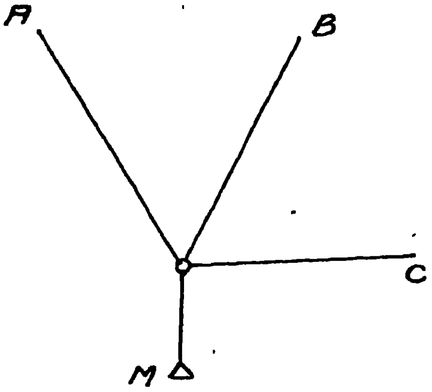
Resulting Corrections.

Bearing to A = + 2″·26. Bearing to B = − 1″·78.

CORRECTIONS TO CENTRE—*continued.*

MANOUTSA. No. 238.

Instrument eccentrically placed.



M … Beacon.
A … Mt. Anderson.
B … Thama Koosh.
C … Iron Crown.

Data.

$d = 8{\cdot}06$ feet.

	°	′	Log. Distances.
Bearing to Beacon =	0	0	—
,, A =	145	5	5·3674
,, B =	206	53	5·3619
,, C =	267	14	5·4615

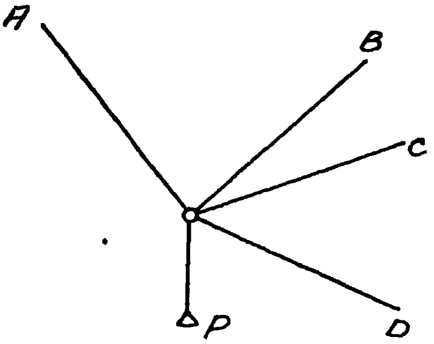
Resulting Corrections.

″
Bearing to A = + 4·09.
,, B = − 3·26.
,, C = − 5·74.

For eccentric heliograph at Thama Koosh, see under that station.

PORTUGAL. No. 240.

Instrument eccentrically placed.



P … Beacon.
A … Matala.
B … Schnell's Kop.
C … Iron Crown.
D … Thama Koosh.

Data.

$d = 5{\cdot}27$ feet.

	°	′	Log. Distances.
Bearing to Beacon =	0	0	—
,, A =	138	6	5·2119
,, B =	227	29	5·4349
,, C =	242	27	5·3851
,, D =	294	23	5·5247

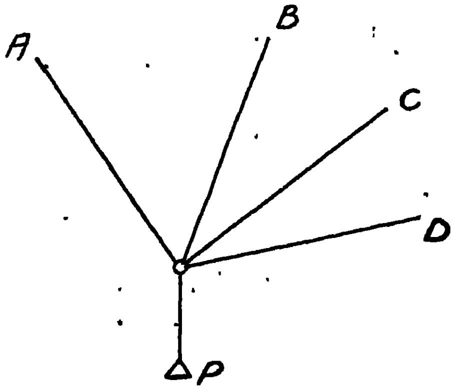
Resulting Corrections.

″ ″
Bearing to A = + 4·46. Bearing to C = − 3·97.
,, B = − 2·94. ,, D = − 2·96.

For eccentric heliograph at Thama Koosh, see under that station.

PONT. No. 250.

Instrument eccentrically placed.



P … Beacon.
A … Dogola.
B … Lejuma.
C … Blaauwberg.
D … Dwarsberg.

Data.

$d = 12{\cdot}55$ feet.

	°	′	Log. Distances.
Bearing to Beacon =	0	0	—
,, A =	128	32	5·2494
,, B =	200	46	5·4682
,, C =	229	40	5·4808
,, D =	258	49	5·3800

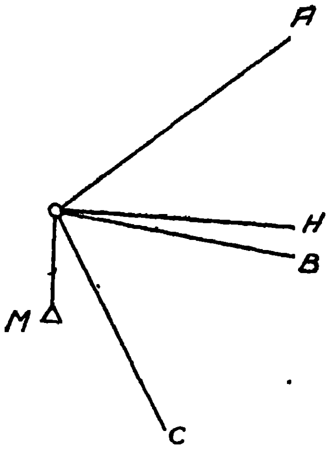
CORRECTIONS TO CENTRES—*continued.*

Resulting Corrections.

Bearing to A = + 11″·40.　　Bearing to C = − 6″·52.
„ B = − 3·12.　　„ D = − 10·59.

CAMP. No. 256.

Instrument eccentrically placed.



M ... Beacon.
A ... Muckleneuk.
H ... Cable Hill.
B ... Meintjes Kop.
C ... Koedoespoort.

Data.

d = 5·72 feet.

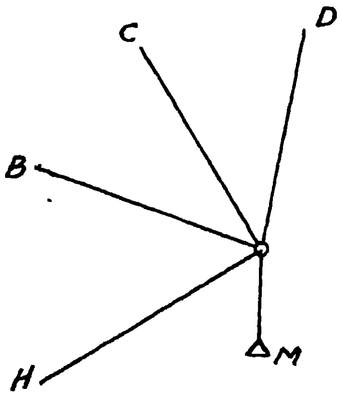
	°	′	Log. Distances.
Bearing to Beacon =	0	0	—
„ A =	228	35	4·1622
„ H =	271	9	4·5806
„ B =	273	6	4·1704
„ C =	331	31	4·1192

Resulting Corrections.

Bearing to A = − 60″·91.　　Bearing to B = − 79″·57.
„ H = − 30·98.　　„ C = − 42·76.

MUCKLENEUK. No. 253.

Instrument eccentrically placed.



M ... Beacon.
H ... Cable Hill.
B ... Meintjes Kop.
C ... Koedoespoort.
D ... Camp.

Data.

d = 5·41 feet.

	°	′	Log. Distances.
Bearing to Beacon =	0	0	—
„ H =	67	57	4·4636
„ B =	116	33	4·0458
„ C =	149	21	4·3360
„ D =	185	37	4·1622

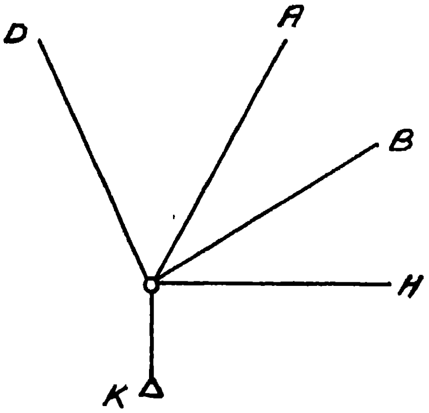
Resulting Corrections.

Bearing to H = + 35″·56.　　Bearing to C = + 26″·25.
„ B = + 89·82.　　„ D = − 7·52.

CORRECTIONS TO CENTRES—*continued.*

KOEDOESPOORT. No. 255.

Instrument eccentrically placed.



K ... Beacon.
D ... Camp.
A ... Muckleneuk.
B ... Meintjes Kop.
H ... Cable Hill.

Data.

$d = 7{\cdot}06$ feet.

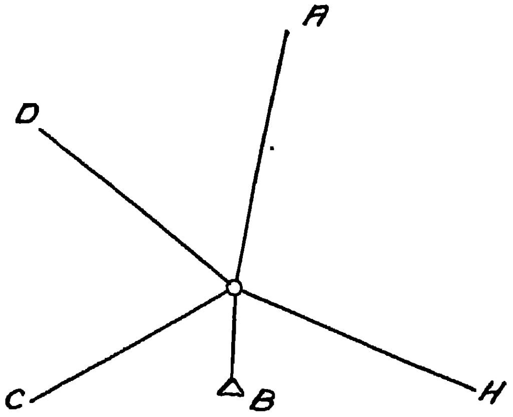
		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ D	=	169	54	4·1192
„ A	=	210	41	4·3360
„ B	=	236	42	4·1374
„ H	=	269	34	5·5262

Resulting Corrections.

″	″
Bearing to D = + 19·40.	Bearing to B = − 88·70.
„ A = − 34·28.	„ H = − 43·35.

MEINTJES KOP. No. 254.

Instrument eccentrically placed.



B ... Beacon.
C ... Koedoespoort.
D ... Camp.
A ... Muckleneuk.
H ... Cable Hill.

Data.

$d = 5{\cdot}62$ feet.

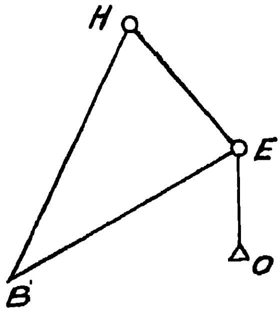
		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ C	=	65	39	4·1374
„ D	=	120	26	4·1704
„ A	=	186	50	4·0459
„ H	=	297	13	4·3668

Resulting Corrections.

″	″
Bearing to C = + 76·97.	Bearing to A = − 12·43.
„ D = + 67·51.	„ H = − 44·30.

BLIJVOORUITZICHT. No. 97.

Eccentric heliograph at Johannesburg.



O ... Johannesburg.
H ... Heliograph.
B ... Blijvooruitzicht.
E ... Instrument.

Data.

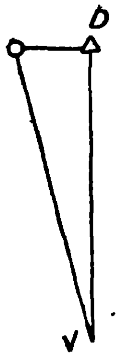
HE = 11·46 feet.   EO = 4·33 feet.

		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ B	=	68	14	5·3825
„ H	=	135	55	—

Resulting Correction.

Bearing to H = + 12″·52.

VLIEGENKRAAL. No. 101.

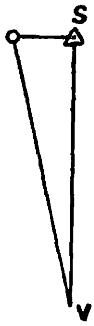


Eccentric heliograph at Doornkop :—The projection of the line observed from Vliegenkraal passes 0·17 feet to the east of Doornkop Beacon.

V ... Vliegenkraal. D ... Doornkop.

$d = 0{\cdot}17$ feet. Log. distance, 5·265.

Correction to bearing to helio = + 0″·19.



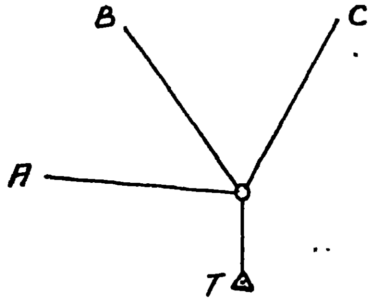
Eccentric heliograph at Spitzkop II :—The signal light from Spitzkop II to Vliegenkraal was 2 inches out of line, so that the observed bearing to Spitzkop II from Vliegenkraal requires the correction + 0″·14.

V ... Vliegenkraal. S ... Spitzkop II.

$d = 0{\cdot}167$ feet. Log. distance = 5·4041.

THAMA KOOSH. No. 237.

At this station the instrument was mounted in a more convenient position than that occupied by the beacon. On the completion of the observations, the beacon tube was erected on the point which the instrument had occupied. Thus there are corrections due, to the observed bearings of Thama Koosh, at Portugal, Iron Crown, and Manoutsa for eccentricity of signals.



T ... Original Beacon. B ... Iron Crown.
A ... Portugal. C ... Manoutsa.

Data.

$d = 15{\cdot}55$ feet.

		°	′	Log. Distances.
Bearing to Beacon	=	0	0	—
„ A	=	92	8	5·5248
„ B	=	138	3	5·4250
„ C	=	208	57	5·3619

Resulting Corrections.

At Portugal = − 9″·58.
„ Iron Crown = − 8·06.
„ Manoutsa = + 6·75.

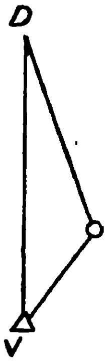
IRON CROWN. No. 239.

Eccentric heliograph at Thama Koosh, see under that station.

Corrections to Centre—*continued.*

Tafel Kop (D.K.) No. 70.

Leaning beacon at Vlakfontein.



D ... Tafel Kop. V ... Vlakfontein.

Data.

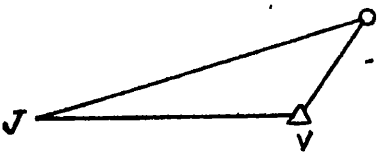
d = 0·861 feet.

	°	′	Log. Distance.
Bearing of Beacon Top =	0	0	—
„ D =	330	30	5·2901

Correction to observed bearing = + 0″·44.

Baatjes Bult. No. 69.

Leaning beacon at Vlakfontein.



J ... Baatjes Bult. V ... Vlakfontein

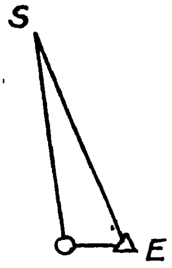
Data.

d = 0·861 feet.

	°	′	Log. Distance.
Bearing of Beacon Top =	0	0	—
„ J =	239	15	4·9879

Correction to observed bearing = + 1″·54.

Spitzkop II. No. 102.



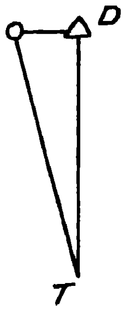
Leaning beacon at Elandskop II:—The disc of the beacon was leaning 1½ inches towards Liebenberg Stroom.

S ... Spitzkop II. E ... Elandskop II.

Angle at E = 62°. Log. distance = 4·9597.

Correction to observed bearing = — 0″·25.

Thaba Tsueu. No. 119.



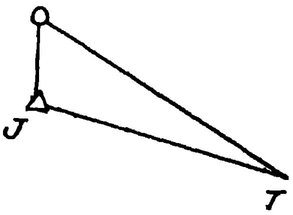
Leaning beacon at Dikhoele:—The beacon Dikhoele was found to be leaning in such a way as to decrease the apparent bearing of the point at Thaba Tsueu by an arc whose linear measure was 0·16 feet.

T ... Thaba Tsueu. D ... Dikhoele.

Angle at D = 90°. Log. distance = 4·7709.

Correction to observed bearing = + 0″·56.

CORRECTIONS TO CENTRE—*continued.*

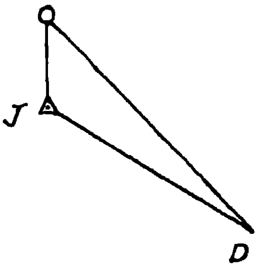


Leaning beacon at Jammersburg:—The beacon Jammersberg was found to be leaning from the point Aasvogel Kop. The displacement of the disc was 0·075 feet.

T ... Thaba Tsueu. J ... Jammersberg.

Angle at J = 107° 38′. Log. distance = 5·1312.

Correction to observed bearing = − 0″·11.



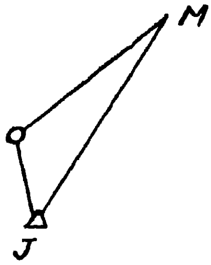
DIKHOELE. No. 121.

Leaning beacon at Jammersberg. See Thaba Tsueu.

D ... Dikhoele. J ... Jammersberg.

Angle at J = 130° 27′. Log. distance = 4·9896.

Correction to observed bearing = − 0″·12.



MABULA. No. 117.

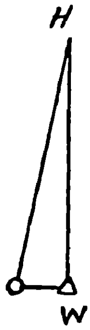
Leaning beacon at Jammersberg. See Thaba Tsueu.

M ... Mabula. J ... Jammersberg.

Angle at J = 32° 18′. Log. distance = 5·1854.

Correction to observed bearing = − 0″·05.

HELVELYN. No. 129.



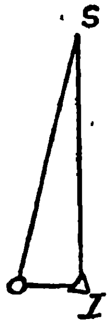
Leaning beacon at Waschbank Peak:—The beacon Waschbank Peak was found to be leaning in such a way as to increase the apparent bearing of the point at Helvelyn by an arc whose linear measure was 0·07 feet.

H ... Helvelyn. W ... Waschbank Peak.

Angle at W = 90°. Log. distance = 5·3200.

Correction to observed bearing = − 0″·07.

SCHNELL'S KOP. No. 241.



Leaning beacon at Iron Crown:—The beacon Iron Crown was found to be leaning in such a way as to increase the apparent bearing of the point at Schnell's Kop by an arc whose linear measure was 0·063 feet.

S ... Schnell's Kop. I ... Iron Crown.

Angle at I = 90°. Log. distance = 4·8640.

Correction to observed bearing = − 0″·18.

ADJUSTMENT OF FIGURES.

4. (A.) With one exception, the complex figures of the triangulation were adjusted by the method described in the "Great Trigonometrical Survey of India," Vol. II., pp. 104-6, and also in the "Report on the Geodetic Survey of South Africa," Vol. I., pp. 116-126. The exception is Figure X., which was adjusted by the method described in Vol. III. of the "Geodetic Survey of South Africa," pp. 20-22. Methods of adjustment.

(B.) In general, a simultaneous solution was made of the whole of a figure. The exceptions are :— Exceptions.

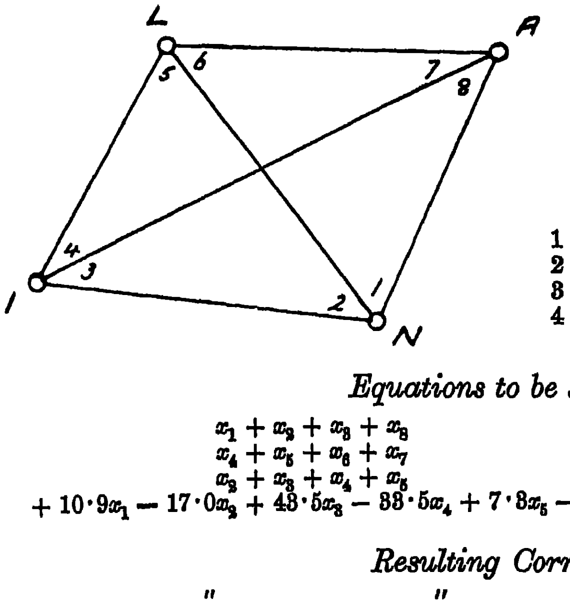
1. The figure surrounding the Wepener Base (Figures IX. and X). Figure IX. was adjusted for Mr. Simms' angles before Captain Gordon's observations in the neighbourhood reached the computing office. When these were received it was seen that the triangles in Figures IX. and X. were involved, but as it was evident that the positions of the stations would be little altered thereby, and in view of the necessity for completing the work as speedily as possible, it was not considered desirable to make a simultaneous solution of the whole figure. The triangle Jammersberg, Thaba Tsueu, Gobo Gobo, was therefore considered fixed by the adjustment of Figure IX. With this condition a simultaneous solution was then obtained for Figure X.
2. Figures XII. and XIII. The angle at Aasvogel Kop, between Tarantal Kop and Boshof Hill, was adjusted in Figure XII. for Captain Gordon's observations on eight arcs, and considered fixed in Figure XIII., for Captain Ley's observations on four arcs.
3. Figures XXIV. and XXV. (Secondary Triangulation). The triangle Cable Hill, Muckleneuk, Meintjes Kop, adjusted in Figure XXIV., for measures with the 8-inch theodolite, was taken as fixed in Figure XXV., measured with the 6-inch theodolite.

(C.) The data and results of solution for the various figures are given in the following pages :— Results.

Figural Equations.

NEWCASTLE TO BELFAST.

Figure I.



L ... Langberg I.
A ... Hlamimpesi Berg.
N ... Nthabankulu.
I ... Inkwelo.

Observed Angles.

	°	′	″		°	′	″
1 =	62	32	14·13	5 =	70	51	38·87
2 =	51	11	31·34	6 =	45	25	22·61
3 =	25	49	58·10	7 =	31	36	5·37
4 =	32	6	55·67	8 =	40	26	20·27

Equations to be satisfied.

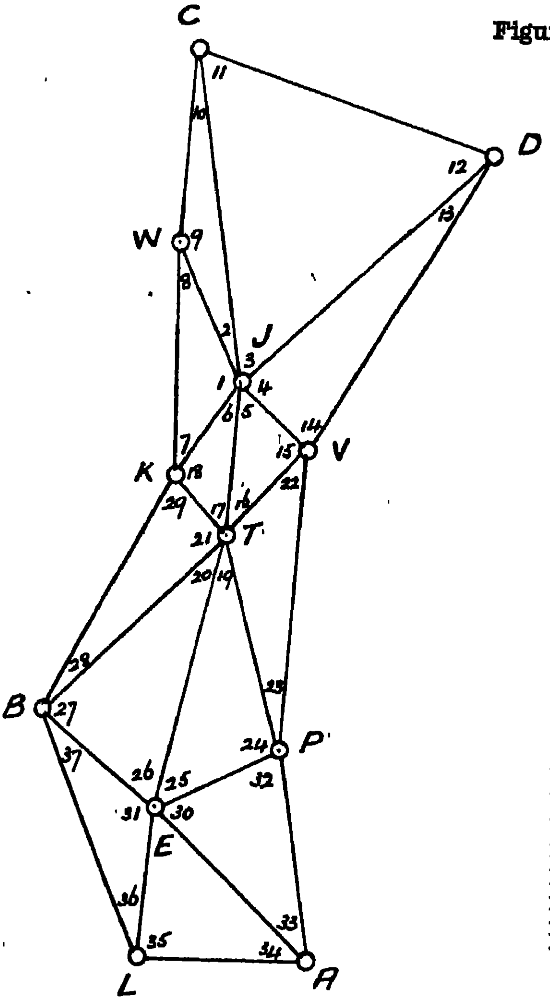
$$x_1 + x_2 + x_3 + x_8 \qquad - 0{\cdot}03 = 0$$
$$x_4 + x_5 + x_6 + x_7 \qquad - 1{\cdot}37 = 0$$
$$x_2 + x_3 + x_4 + x_5 \qquad - 0{\cdot}42 = 0$$
$$+ 10{\cdot}9x_1 - 17{\cdot}0x_2 + 43{\cdot}5x_3 - 33{\cdot}5x_4 + 7{\cdot}3x_5 - 20{\cdot}8x_6 + 34{\cdot}2x_7 - 24{\cdot}7x_8 - 9{\cdot}00 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = + 0{\cdot}10$	$x_3 = + 0{\cdot}03$	$x_5 = + 0{\cdot}30$	$x_7 = + 0{\cdot}50$
$x_2 = - 0{\cdot}11$	$x_4 = + 0{\cdot}20$	$x_6 = + 0{\cdot}37$	$x_8 = + 0{\cdot}01$

FIGURAL EQUATIONS—NEWCASTLE TO BELFAST—*continued.*

Figure II.



C … Verloren Vlei.
D … Tafelkop (D.K.).
W … Wonderfontein.
J … Baatjes Bult.
V … Vlakfontein.
K … Sterkfontein.
T … Tafelkop (Ermelo).
B … Blaauwkop.
E … Elandsberg III.
P … Spitzkop I.
L … Langberg I.
A … Hlanimpesi Berg.

Observed Angles.

	°	′	″		°	′	″
1 =	90	10	32·82	20 =	41	32	45·38
2 =	34	18	45·87	21 =	120	58	24·80
3 =	58	28	16·12	22 =	40	10	14·36
4 =	62	29	55·56	23 =	62	50	26·32
5 =	92	28	59·55	24 =	88	30	8·05
6 =	22	3	30·53	25 =	45	50	26·73
7 =	55	23	8·37	26 =	65	22	53·50
8 =	34	26	22·36	27 =	73	4	25·77
9 =	115	57	48·63	28 =	14	27	12·97
10 =	29	43	33·98	29 =	44	34	24·55
11 =	46	49	51·30	30 =	72	39	56·28
12 =	74	42	5·99	31 =	116	5	15·62
13 =	26	15	0·81	32 =	60	56	7·34
14 =	91	15	7·99	33 =	46	24	1·49
15 =	54	54	56·47	34 =	26	47	52·81
16 =	82	36	7·58	35 =	93	10	42·57
17 =	42	13	47·09	36 =	41	51	56·81
18 =	115	42	43·34	37 =	22	2	49·54
19 =	45	39	29·83				

Equations to be satisfied.

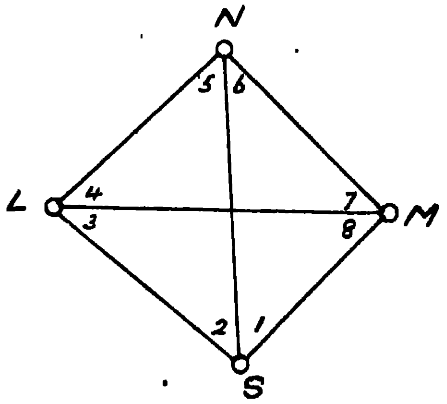
$$x_1 + x_7 + x_8 - 0{\cdot}76 = 0$$
$$x_2 + x_9 + x_{10} + 2{\cdot}34 = 0$$
$$x_3 + x_{11} + x_{12} + 0{\cdot}47 = 0$$
$$x_4 + x_{13} + x_{14} - 0{\cdot}20 = 0$$
$$x_5 + x_{15} + x_{16} - 1{\cdot}15 = 0$$
$$x_6 + x_{17} + x_{18} - 0{\cdot}40 = 0$$
$$x_{19} + x_{24} + x_{25} + 0{\cdot}53 = 0$$
$$x_{20} + x_{26} + x_{27} - 0{\cdot}27 = 0$$
$$x_{21} + x_{28} + x_{29} - 0{\cdot}11 = 0$$
$$x_{30} + x_{32} + x_{33} + 0{\cdot}30 = 0$$
$$x_{31} + x_{36} + x_{37} - 0{\cdot}34 = 0$$
$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + 0{\cdot}38 = 0$$
$$-x_{16} - x_{17} - x_{19} - x_{20} - x_{21} + x_{22} + x_{23} + 0{\cdot}58 = 0$$
$$-x_{25} - x_{26} - x_{30} - x_{31} + x_{34} + x_{35} + 1{\cdot}06 = 0$$
$$\begin{aligned}+ 14{\cdot}5x_7 - 80{\cdot}7x_8 - 10{\cdot}2x_9 - 36{\cdot}9x_{10} + 19{\cdot}8x_{11} - 5{\cdot}7x_{12} + 42{\cdot}7x_{13}& \\ + 0{\cdot}5x_{14} + 14{\cdot}7x_{15} - 33{\cdot}0x_{16} + 23{\cdot}2x_{17} + 10{\cdot}2x_{18}& - 79 = 0\end{aligned}$$
$$\begin{aligned}- 1{\cdot}0x_5 - 52{\cdot}0x_6 - 14{\cdot}7x_{15} - 10{\cdot}2x_{18} + 24{\cdot}9x_{22} - 10{\cdot}8x_{23} + 0{\cdot}5x_{24}& \\ - 20.4x_{25} + 9{\cdot}6x_{26} - 6{\cdot}4x_{27} + 81{\cdot}7x_{28} - 21{\cdot}3x_{29}& + 67 = 0\end{aligned}$$
$$\begin{aligned}+ 20{\cdot}6x_{19} - 23{\cdot}7x_{20} - 0{\cdot}5x_{24} + 6{\cdot}4x_{27} + 11{\cdot}7x_{32} - 20{\cdot}1x_{33} + 41{\cdot}7x_{34}& \\ + 1{\cdot}1x_{35} + 23{\cdot}5x_{36} - 52{\cdot}0x_{37}& - 24 = 0\end{aligned}$$

Resulting Corrections.

″	″	″	″
$x_1 = + 0{\cdot}26$	$x_{11} = - 0{\cdot}10$	$x_{20} = - 0{\cdot}07$	$x_{29} = + 0{\cdot}09$
$x_2 = - 0{\cdot}65$	$x_{12} = - 0{\cdot}25$	$x_{21} = + 0{\cdot}16$	$x_{30} = + 0{\cdot}11$
$x_3 = - 0{\cdot}17$	$x_{13} = + 0{\cdot}19$	$x_{22} = - 0{\cdot}33$	$x_{31} = + 0{\cdot}30$
$x_4 = - 0{\cdot}01$	$x_{14} = + 0{\cdot}05$	$x_{23} = - 0{\cdot}15$	$x_{32} = - 0{\cdot}12$
$x_5 = - 0{\cdot}09$	$x_{15} = + 0{\cdot}03$	$x_{24} = - 0{\cdot}48$	$x_{33} = - 0{\cdot}42$
$x_6 = + 0{\cdot}21$	$x_{16} = - 0{\cdot}15$	$x_{25} = - 0.01$	$x_{34} = + 0{\cdot}05$
$x_7 = + 0{\cdot}31$	$x_{17} = + 0{\cdot}24$	$x_{26} = + 0{\cdot}29$	$x_{35} = - 0{\cdot}36$
$x_8 = + 0{\cdot}06$	$x_{18} = + 0{\cdot}04$	$x_{27} = + 0{\cdot}07$	$x_{36} = + 0{\cdot}19$
$x_9 = - 0{\cdot}73$	$x_{19} = - 0{\cdot}09$	$x_{28} = - 0{\cdot}41$	$x_{37} = - 0{\cdot}55$
$x_{10} = - 0{\cdot}88$			

FIGURAL EQUATIONS—NEWCASTLE TO BELFAST—*continued.*

Figure III.



L ... Langekloof.
N ... North end, Belfast Base.
M ... Maré's Kop.
S ... South end, Belfast Base.

Observed Angles.

	°	′	″		°	′	″
1 =	46	45	39·59	5 =	82	85	40·48
2 =	54	29	4·48	6 =	54	8	55·02
3 =	49	8	17·78	7 =	49	28	27·20
4 =	48	46	57·83	8 =	29	36	59·09

Equations to be satisfied.

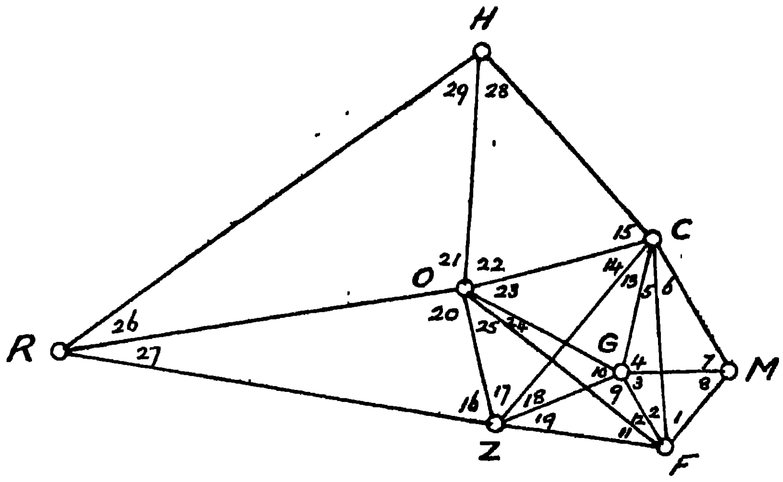
$$x_1 + x_2 + x_3 + x_8 + 0{\cdot}49 = 0$$
$$x_2 + x_3 + x_4 + x_5 + 0{\cdot}12 = 0$$
$$x_4 + x_5 + x_6 + x_7 - 0{\cdot}02 = 0$$
$$+ 19{\cdot}8x_1 - 15{\cdot}0x_2 + 18{\cdot}2x_3 - 22{\cdot}0x_4 + 32{\cdot}9x_5 - 15{\cdot}2x_6 + 18{\cdot}0x_7 - 37{\cdot}0x_8 + 78{\cdot}6 = 0$$

Resulting Corrections.

$x_1 = - 0{\cdot}64$
$x_2 = + 0{\cdot}18$
$x_3 = - 0{\cdot}42$
$x_4 = + 0{\cdot}55$

$x_5 = - 0{\cdot}43$
$x_6 = + 0{\cdot}25$
$x_7 = - 0{\cdot}35$
$x_8 = + 0{\cdot}39$

Figure IV.



R ... Rheuosterkop I.
H ... Paardekop I.
O ... Groot Riet Vlei.
C ... Verloren Vlei.
Z ... Panplaats.
G ... Langekloof.
F ... Belfast.
M ... Maré's Kop.

Observed Angles.

	°	′	″		°	′	″		°	′	″
1 =	85	42	51·25	11 =	32	81	4·74	21 =	100	39	55·72
2 =	35	2	59·95	12 =	18	49	33·92	22 =	65	43	39·12
3 =	73	57	44·19	13 =	22	58	58·15	23 =	57	26	17·16
4 =	58	25	13·12	14 =	25	16	15·68	34 =	7	56	59·40
5 =	12	34	5·59	15 =	66	13	32·81	25 =	43	45	25·25
6 =	25	25	42·81	16 =	79	54	34·71	26 =	26	37	48·29
7 =	83	35	0·72	17 =	45	35	5·49	27 =	15	37	44·97
8 =	35	16	26·64	18 =	33	23	44·53	28 =	48	2	51·18
9 =	103	54	39·18	19 =	24	44	40·94	29 =	52	42	26·11
10 =	49	18	47·96	20 =	84	27	48·35				

FIGURAL EQUATIONS—NEWCASTLE TO BELFAST—*continued.*

Equations to be Satisfied.

$$x_1 + x_2 + x_3 + x_8 + 1·42 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 0·77 = 0$$
$$x_2 + x_3 + x_4 + x_5 + 2·10 = 0$$
$$+ 29·3x_1 - 30·0x_2 + 6·1x_3 - 13·0x_4 + 94·4x_5 - 44·2x_6 + 2·4x_7 - 29·8x_8 - 33·5 = 0$$
$$x_2 + x_5 + x_{11} + x_{12} + x_{13} + x_{18} + x_{19} - 0·14 = 0$$
$$x_9 + x_{11} + x_{12} + x_{19} - 2·02 = 0$$
$$+ 30·0x_2 - 94·4x_5 - 16·9x_{11} - 16·9x_{12} + 49·9x_{13} - 31·9x_{18} + 45·7x_{19} + 37·0 = 0$$
$$x_9 + x_{10} + x_{12} + x_{24} + 0·01 = 0$$
$$x_{10} + x_{17} + x_{18} + x_{24} + x_{25} + 1·46 = 0$$
$$- 16·9x_{11} + 44·9x_{12} - 4·1x_{17} - 4·1x_{18} + 45·7x_{19} - 134·2x_{24} + 16·6x_{25} - 50·1 = 0$$
$$x_{14} + x_{17} + x_{23} + x_{24} + x_{25} + 1·00 = 0$$
$$+ 31·0x_{13} - 18·9x_{14} + 4·1x_{17} - 27·8x_{18} + 13·4x_{23} - 16·6x_{24} - 16·6x_{25} - 20·9 = 0$$
$$x_{15} + x_{22} + x_{28} - 1·16 = 0$$
$$x_{21} + x_{26} + x_{29} + 0·68 = 0$$
$$x_{16} + x_{20} + x_{27} - 1·69 = 0$$
$$x_{20} + x_{21} + x_{22} + x_{23} + x_{24} + x_{25} = 0$$
$$+ 44·6x_{14} - 9·3x_{15} + 3·7x_{16} - 20·6x_{17} + 42·0x_{26} - 75·3x_{27} + 18·9x_{28} - 16·0x_{30} + 98·5 = 0$$

Resulting Corrections.

$x_1 = - 0·02''$
$x_2 = - 0·83$
$x_3 = - 0·57$
$x_4 = - 0·62$
$x_5 = - 0·06$
$x_6 = - 0·05$
$x_7 = - 0·06$
$x_8 = + 0·01$

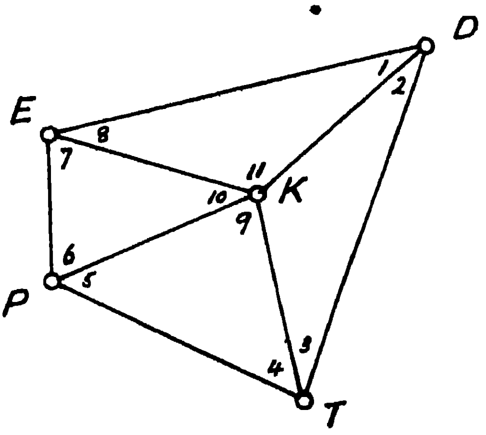
$x_9 = + 0·44''$
$x_{10} = - 0·53$
$x_{11} = + 0·88$
$x_{12} = + 0·38$
$x_{13} = - 0·17$
$x_{14} = - 0·47$
$x_{15} = + 0·41$

$x_{16} = + 0·34''$
$x_{17} = + 0·04$
$x_{18} = - 0·21$
$x_{19} = + 0·28$
$x_{20} = + 0·34$
$x_{21} = - 0·16$
$x_{22} = + 0·35$

$x_{23} = + 0·10''$
$x_{24} = - 0·29$
$x_{25} = - 0·34$
$x_{26} = - 0·47$
$x_{27} = + 0·94$
$x_{29} = + 0·20$
$x_{30} = - 0·03$

BELFAST TO OTTOSHOOP.

Figure V.



K ... Kaalkop I.
D ... Pilandsberg.
T ... Tafelkop.
P ... Onverwacht.
E ... Enzelberg.

Observed Angles.

	°	′	″		°	′	″
1 =	33	41	39·56	7 =	64	22	52·29
2 =	16	42	44·47	8 =	36	31	47·70
3 =	23	15	24·95	9 =	78	3	3·38
4 =	56	14	20·99	10 =	32	8	23·07
5 =	45	42	40·12	11 =	109	46	33·59
6 =	83	28	48·43				

Equations to be Satisfied.

$$x_1 + x_8 + x_{11} - 0·26 = 0$$
$$x_4 + x_5 + x_9 - 0·39 = 0$$
$$x_6 + x_7 + x_{10} + 0·39 = 0$$
$$x_2 + x_3 - x_9 - x_{10} - x_{11} - 0·41 = 0$$
$$+ 31·6x_1 - 70·1x_2 + 49·0x_3 - 14·1x_4 + 20·5x_5 - 2·4x_6 + 10·1x_7 - 28·4x_8 + 44·6 = 0$$

Resulting Corrections.

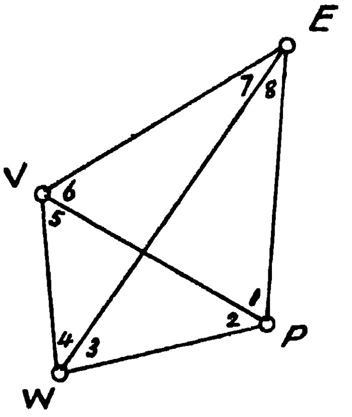
$x_1 = - 0·01''$
$x_2 = + 0·42$
$x_3 = - 0·11$
$x_4 = + 0·24$

$x_5 = + 0·08''$
$x_6 = - 0·07$
$x_7 = - 0·13$
$x_8 = + 0·25$

$x_9 = + 0·07''$
$x_{10} = - 0·19$
$x_{11} = + 0·02$

FIGURAL EQUATIONS—BELFAST TO OTTOSHOOP—*continued.*

Figure VI.



V ... Vergenoeg.
E ... Enzelberg.
P ... Onverwacht.
W ... Witkop I.

Observed Angles.

	°	′	″		°	′	″
1 =	61	33	56·92	5 =	55	27	38·11
2 =	44	30	17·41	6 =	58	52	4·43
3 =	40	38	48·55	7 =	26	17	2·22
4 =	39	23	16·75	8 =	33	16	58·45

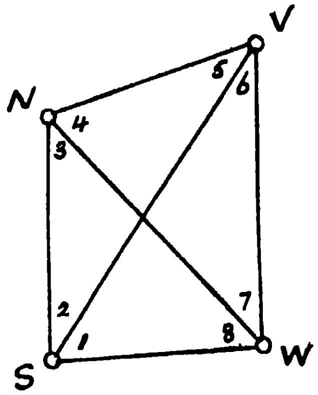
Equations to be satisfied.

$$x_1 + x_2 + x_3 + x_8 - 0 \cdot 30 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 0 \cdot 16 = 0$$
$$x_2 + x_3 + x_4 + x_5 - 0 \cdot 38 = 0$$
$$+ 11 \cdot 4x_1 - 21 \cdot 4x_2 + 24 \cdot 5x_3 - 25 \cdot 6x_4 + 14 \cdot 5x_5 - 12 \cdot 8x_6 + 42 \cdot 6x_7 - 32 \cdot 1x_8 - 44 \cdot 0 = 0$$

Resulting Corrections.

″	″	″
$x_1 = + 0 \cdot 13$	$x_4 = - 0 \cdot 24$	$x_7 = + 0 \cdot 23$
$x_2 = + 0 \cdot 01$	$x_5 = + 0 \cdot 16$	$x_8 = - 0 \cdot 29$
$x_3 = + 0 \cdot 45$	$x_6 = - 0 \cdot 31$	

Figure VII.



N ... North end, Ottoshoop Base.
V ... Vergenoeg.
W ... Witkop I.
S ... South end, Ottoshoop Base.

Observed Angles.

	°	′	″		°	′	″
1 =	50	1	8·95	5 =	40	36	31·32
2 =	24	41	31·89	6 =	17	29	43·09
3 =	26	27	28·32	7 =	33	39	19·02
4 =	88	14	29·42	8 =	78	49	49·76

Equations to be satisfied.

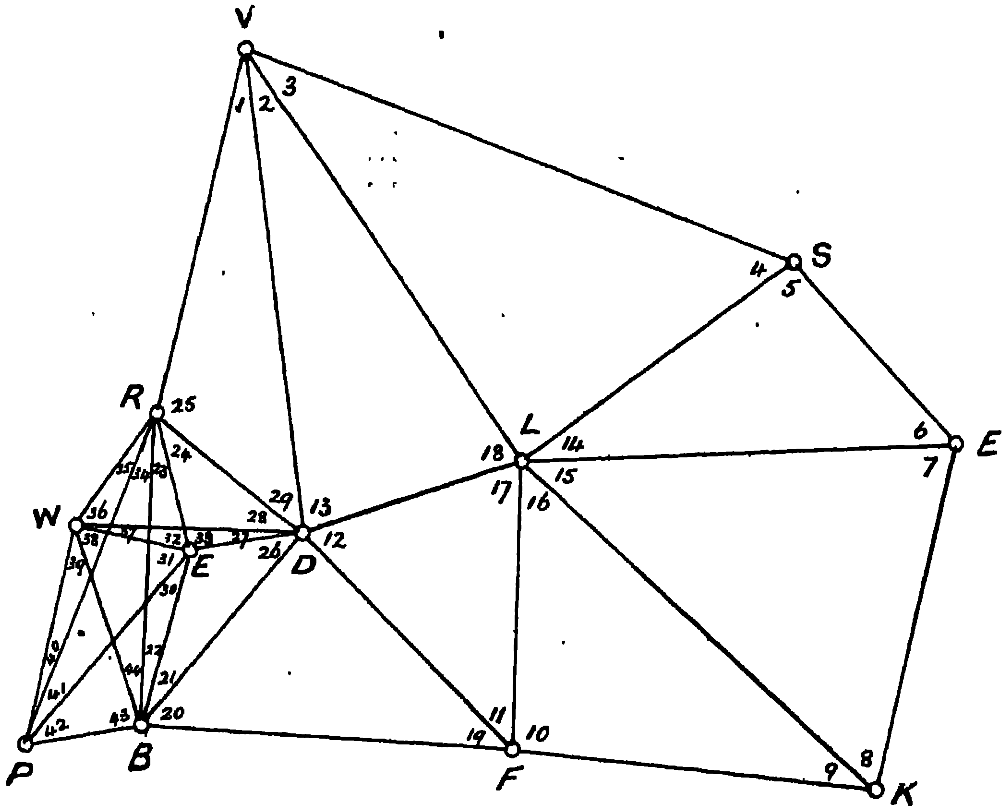
$$x_1 + x_2 + x_3 + x_8 - 1 \cdot 42 = 0$$
$$x_2 + x_3 + x_4 + x_5 + 0 \cdot 50 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 2 \cdot 36 = 0$$
$$+ 17 \cdot 7x_1 - 45 \cdot 8x_2 + 42 \cdot 3x_3 - 0 \cdot 7x_4 + 24 \cdot 6x_5 - 66 \cdot 8x_6 + 31 \cdot 7x_7 - 4 \cdot 1x_8 + 32 = 0$$

Resulting Corrections.

″	″	″
$x_1 = + 0 \cdot 28$	$x_4 = - 0 \cdot 58$	$x_7 = - 0 \cdot 75$
$x_2 = + 0 \cdot 57$	$x_5 = - 0 \cdot 69$	$x_8 = + 0 \cdot 37$
$x_3 = + 0 \cdot 20$	$x_6 = - 0 \cdot 34$	

FIGURAL EQUATIONS—JOHANNESBURG TO KROONSTAD.

Fig. VIII.



V ... Vliegenkraal.
S ... Spitzkop II.
E ... Elandskop II.
K ... Kaffir Kop.

F ... Rietfontein.
L ... Liebenberg Stroom.
D ... Doornkop.
B ... Boschrand.

P ... Braunzijn Kop.
W ... West end Kroonstad Base.
E ... East end Kroonstad Base.
R ... Rhenosterkop II.

Observed Angles.

	°	′	″		°	′	″		°	′	″
1 =	25	46	43·15	16 =	46	5	43·93	31 =	53	32	34·48
2 =	32	16	26·52	17 =	65	49	7·91	32 =	69	7	45·61
3 =	25	59	56·77	18 =	51	47	17·13	33 =	101	45	20·19
4 =	66	35	30·39	19 =	28	30	5·04	34 =	26	10	15·15
5 =	71	46	39·78	20 =	59	29	56·84	35 =	13	40	18·96
6 =	61	55	56·92	21 =	37	50	41·73	36 =	56	43	30·31
7 =	79	19	51·12	22 =	17	15	25·32	37 =	3	49	6·23
8 =	38	4	27·71	23 =	10	29	5·55	38 =	36	55	5·32
9 =	38	26	49·85	24 =	28	55	20·28	39 =	58	9	43·20
10 =	95	27	30·76	25 =	122	37	46·11	40 =	10	42	17·27
11 =	59	12	18·10	26 =	36	10	8·74	41 =	20	40	22·21
12 =	54	58	33·09	27 =	5	17	47·72	42 =	14	39	39·38
13 =	95	56	20·82	28 =	44	1	32·77	43 =	75	47	59·85
14 =	46	17	25·08	29 =	31	35	32·74	44 =	42	41	46·11
15 =	62	35	46·02	30 =	29	35	10·64				

Equations to be satisfied.

$$x_2 + x_{13} + x_{18} - 0·94 = 0$$

$$x_3 + x_4 - x_{14} - x_{15} - x_{16} - x_{17} - x_{18} + 0·97 = 0$$

$$x_5 + x_6 + x_{14} - 0·55 = 0$$

$$x_7 + x_8 + x_{15} + 0·05 = 0$$

$$x_9 + x_{10} + x_{16} + 0·66 = 0$$

$$x_{11} + x_{12} + x_{17} + 0·88 = 0$$

$$+ 33·3x_2 - 43·2x_3 + 9·2x_4 - 6·9x_5 + 11·3x_6 - 4·0x_7 + 26·8x_8 - 26·6x_9 - 2·0x_{10}$$
$$- 12·6x_{11} + 14·7x_{12} + 2·2x_{13} - 30·7 = 0$$

$$- x_{12} - x_{13} + x_{19} + x_{20} - x_{26} - x_{27} - x_{28} - x_{29} - 1·31 = 0$$

$$x_{21} + x_{22} + x_{23} + x_{24} + x_{26} + x_{27} + x_{28} + 0·46 = 0$$

$$x_1 + x_{25} + x_{29} - 0·17 = 0$$

$$+ 43·6x_1 - 33·3x_2 + 12·6x_{11} - 9·4x_{17} + 16·6x_{18} - 38·8x_{19} + 12·4x_{20} - 14·7x_{21}$$
$$- 14·7x_{22} + 25·7x_{23} + 25·7x_{24} + 13·4x_{25} + 29·7 = 0$$

$$x_{22} + x_{23} + x_{30} + x_{31} + x_{32} + 1·23 = 0$$

$$x_{24} + x_{27} + x_{28} + x_{33} + 0·16 = 0$$

FIGURAL EQUATIONS—JOHANNESBURG TO KROONSTAD—*continued.*

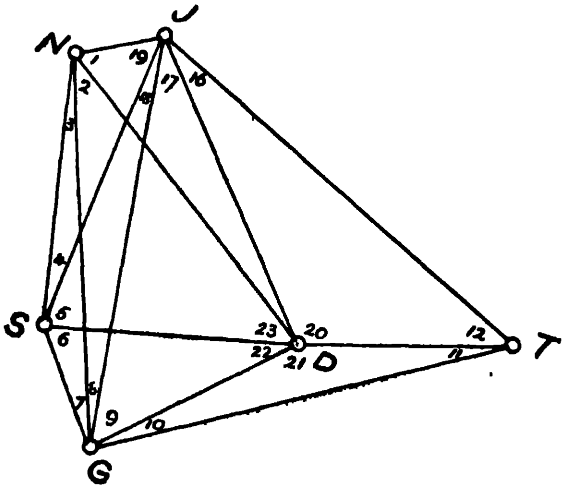
$$+27\cdot1x_{21}-67\cdot8x_{22}+113\cdot7x_{23}-38\cdot1x_{24}-28\cdot8x_{26}+18\cdot1x_{27}+18\cdot1x_{28}-25\cdot1=0$$
$$x_{23}+x_{32}+x_{34}+x_{35}+x_{36}+x_{37}+0\cdot75=0$$
$$x_{23}+x_{24}+x_{28}+x_{34}+x_{35}+x_{36}+1\cdot28=0$$
$$+17\cdot4x_{23}-38\cdot1x_{24}-209\cdot0x_{27}+18\cdot1x_{28}+17\cdot4x_{34}+17\cdot4x_{35}-11\cdot9x_{36}+303\cdot6x_{37}+99\cdot8=0$$
$$x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{44}+0\cdot70=0$$
$$-55\cdot6x_{22}+96\cdot3x_{23}-17\cdot4x_{34}-17\cdot4x_{35}+11\cdot9x_{36}+11\cdot9x_{37}-28\cdot0x_{38}+12\cdot2x_{44}+9\cdot0=0$$
$$x_{34}+x_{41}+x_{42}+x_{43}+x_{44}+0\cdot59=0$$
$$x_{28}+x_{31}+x_{33}+x_{34}+x_{41}+1\cdot18=0$$
$$-89\cdot4x_{33}+85\cdot4x_{28}-28\cdot3x_{34}+55\cdot8x_{41}-80\cdot5x_{42}-21\cdot6x_{43}-21\cdot6x_{44}+25\cdot9=0$$
$$x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+0\cdot52=0$$
$$+17\cdot4x_{23}+15\cdot6x_{31}-8\cdot0x_{32}+17\cdot4x_{34}-69\cdot1x_{35}+76\cdot9x_{40}-34\cdot5x_{41}-12\cdot2=0$$

Resulting Corrections.

	″		″		″		″
x_1 =	+ 0·12	x_{12} =	− 0·49	x_{23} =	− 0·17	x_{34} =	− 0·10
x_2 =	+ 0·44	x_{13} =	+ 0·05	x_{24} =	− 0·37	x_{35} =	− 0·16
x_3 =	− 0·25	x_{14} =	+ 0·28	x_{25} =	+ 0·16	x_{36} =	− 0·19
x_4 =	− 0·12	x_{15} =	+ 0·06	x_{26} =	− 0·27	x_{37} =	− 0·08
x_5 =	+ 0·11	x_{16} =	− 0·10	x_{27} =	+ 0·38	x_{38} =	− 0·01
x_6 =	+ 0·16	x_{17} =	− 0·09	x_{28} =	− 0·29	x_{39} =	− 0·08
x_7 =	− 0·09	x_{18} =	+ 0·45	x_{29} =	− 0·11	x_{40} =	0·00
x_8 =	− 0·02	x_{19} =	+ 0·32	x_{30} =	− 0·40	x_{41} =	− 0·39
x_9 =	− 0·31	x_{20} =	+ 0·26	x_{31} =	− 0·46	x_{42} =	+ 0·12
x_{10} =	− 0·25	x_{21} =	+ 0·41	x_{32} =	− 0·05	x_{43} =	− 0·06
x_{11} =	− 0·30	x_{22} =	− 0·15	x_{33} =	+ 0·12	x_{44} =	− 0·16

KROONSTAD TO WEPENER.

Figure IX.



J … Jammersberg.
T … Thaba Tsueu.
G … Gobo Gobo.
S … South end Wepener Base
N … North end Wepener Base.
D … Dikhoele.

Observed Angles.

	°	′	″		°	′	″		°	′	″
1 =	59	2	38·04	8 =	9	7	13·77	18 =	5	27	1·73
2 =	41	42	17·28	9 =	62	56	16·30	19 =	64	40	50·30
3 =	2	1	4·26	10 =	5	23	34·75	20 =	117	16	2·99
4 =	12	33	9·55	11 =	6	44	15·32	21 =	167	52	11·32
5 =	81	26	57·09	12 =	39	55	5·93	22 =	28	57	41·78
6 =	79	16	6·12	16 =	22	48	52·16	23 =	42	16	31·90
7 =	4	42	41·58	17 =	42	11	58·14				

FIGURAL EQUATIONS—KROONSTAD TO WEPENER—*continued.*

Equations to be satisfied.

$$\begin{aligned}
&x_9 + x_{10} + x_{11} + x_{12} + x_{16} + x_{17} &- 0{\cdot}47 = 0\\
&x_9 + x_{17} - x_{20} - x_{21} &- 1{\cdot}51 = 0\\
&x_1 + x_2 + x_8 + x_{18} + x_{19} &+ 0{\cdot}72 = 0\\
&x_3 + x_4 + x_5 + x_6 + x_7 &- 1{\cdot}46 = 0\\
&x_1 + x_2 + x_3 + x_4 + x_{19} &- 0{\cdot}85 = 0\\
&x_5 + x_{17} + x_{18} - x_{20} - x_{21} - x_{22} &- 0{\cdot}44 = 0\\
&x_1 + x_{17} + x_{18} + x_{19} - x_{20} - x_{21} - x_{22} - x_{23} &- 0{\cdot}14 = 0\\
&x_{12} + x_{16} + x_{20} &- 0{\cdot}13 = 0\\
&-273{\cdot}0\,x_4 - 178{\cdot}5\,x_5 - 178{\cdot}5\,x_6 - 255{\cdot}5\,x_7 + 131{\cdot}2\,x_8 - 7{\cdot}6\,x_{18} + 2{\cdot}8\,x_{10} &+ 4{\cdot}76 = 0\\
&- 63{\cdot}3\,x_5 - 60{\cdot}2\,x_6 - 85{\cdot}5\,x_7 - 85{\cdot}5\,x_8 + 10{\cdot}8\,x_9 - 11{\cdot}4\,x_{20} - 11{\cdot}4\,x_{21} - 17{\cdot}1\,x_{22} &- 7 = 0\\
&+ 12{\cdot}6\,x_1 - 22{\cdot}0\,x_2 - 22{\cdot}0\,x_3 - 1{\cdot}5\,x_4 - 4{\cdot}6\,x_5 + 27{\cdot}8\,x_{17} + 27{\cdot}8\,x_{18} + 8{\cdot}6\,x_{19} &+ 7 = 0\\
&+ 8{\cdot}3\,x_9 - 214{\cdot}8\,x_{10} + 40{\cdot}3\,x_{16} - 9{\cdot}8\,x_{17} + 10{\cdot}8\,x_{20} - 98{\cdot}0\,x_{21} &- 153 = 0
\end{aligned}$$

Resulting Corrections.

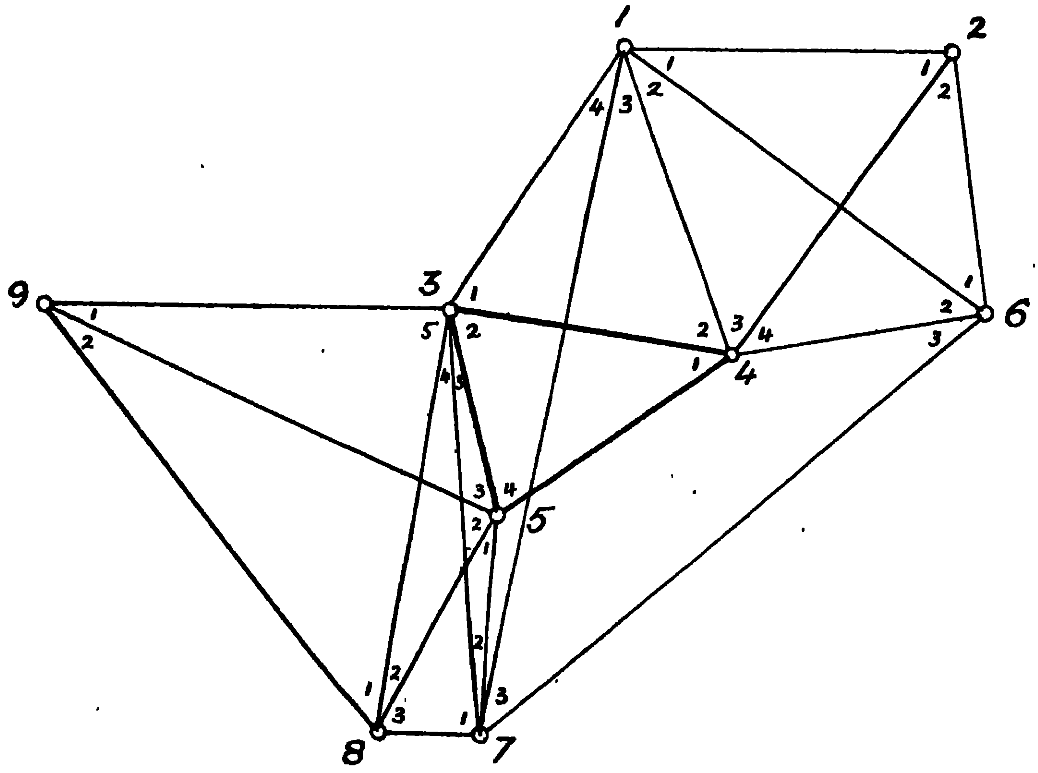
″
$x_1 = -0{\cdot}04$
$x_2 = +0{\cdot}22$
$x_3 = -0{\cdot}12$
$x_4 = +0{\cdot}82$
$x_5 = +0{\cdot}07$

″
$x_6 = +0{\cdot}25$
$x_7 = +0{\cdot}44$
$x_8 = -0{\cdot}64$
$x_9 = +0{\cdot}64$
$x_{10} = -0{\cdot}41$

″
$x_{11} = -0{\cdot}19$
$x_{12} = +0{\cdot}12$
$x_{16} = +0{\cdot}16$
$x_{17} = +0{\cdot}14$
$x_{18} = -0{\cdot}22$

″
$x_{19} = -0{\cdot}04$
$x_{20} = -0{\cdot}15$
$x_{21} = -0{\cdot}58$
$x_{22} = +0{\cdot}28$
$x_{23} = +0{\cdot}15$

Figure X.



1 ... Mabula.
2 ... Machache.
3 ... Jammersberg.

4 ... Thaba Tsueu.
5 ... Gobo Gobo.
6 ... Thaba Putsua.

7 ... Aasvogel Berg.
8 ... Koesberg.
9 ... Lemoenfontein.

Observed Angles.

	°	′	″		°	′	″		°	′	″
$1_1 =$	32	18	32·62	$3_5 =$	84	8	57·58	$6_3 =$	27	18	59·92
$1_2 =$	37	39	5·54	$4_2 =$	56	57	9·16	$7_1 =$	69	16	25·29
$1_3 =$	28	46	26·47	$4_3 =$	60	11	9·12	$7_2 =$	6	59	56·31
$1_4 =$	18	56	40·22	$4_4 =$	88	16	5·52	$7_3 =$	42	21	59·37
$2_1 =$	49	51	21·24	$5_1 =$	16	30	52·91	$8_1 =$	46	45	19·80
$2_2 =$	45	26	34·59	$5_2 =$	94	35	5·92	$8_2 =$	15	15	48·84
$3_1 =$	75	19	49·28	$5_3 =$	54	32	48·10	$8_3 =$	87	12	45·90
$3_3 =$	7	21	21·06	$6_1 =$	52	28	38·14	$9_1 =$	25	42	1·07
$3_4 =$	8	15	1·49	$6_2 =$	43	53	47·16	$9_2 =$	28	28	50·52

FIGURAL EQUATIONS—KROONSTAD TO WEPENER—*continued.*

Fixed Angles.

$3_2 = 65^\circ\ 0'\ 50''\cdot60$ $\quad 4_1 = 46^\circ\ 39'\ 21''\cdot18$ $\quad 5_4 = 68^\circ\ 19'\ 51''\cdot28$

Approximate Co-ordinates Origin ϕ_0 29° 45′, L_0 — 28°.

	Y.	X.
(1)	+ 233863·7	− 148994·0
(2)	+ 33206·2	− 142511·8
(3)	+ 309394·55	− 15629·27
(4)	+ 178643·30	+ 19051·63
(5)	+ 290770·68	+ 88586·35
(6)	+ 25053·0	− 7810·8
(7)	+ 298950·7	+ 199523·0
(8)	+ 329065·0	+ 189770·0
(9)	+ 508229·0	− 14326·0

FIGURAL EQUATIONS—KROONSTAD TO WEPENER—*continued.*

Observation Equations.

	y_3.	y_4.	y_5.	x_5.	y_6.	x_6.	y_7.	x_7.	y_8.	x_8.	y_9.	x_9.	n.
$x(1)_1$					+0·459	+0·676							+0·10
$x(1)_2$	−0·488	+1·253	+0·344	+0·364	−0·459	−0·676							−0·38
$x(1)_3$	+0·488	−1·253	−0·844	−0·364			+0·572	−0·107					+0·74
$x(1)_4$	+1·433	−0·573	+0·309	−0·663			−0·572	+0·107					−0·90
$x(2)_1$	−0·858	−0·453	+0·601	+0·686									−0·32
$x(2)_2$	+0·853	+0·453	−0·601	−0·636	−1·520	−0·092							+0·25
$x(3)_1$	−3·214	+0·277	+1·768	+0·663									−0·15
$x(3)_2$	+0·842	+0·256	−2·055	−0·047			+0·957	+0·046					+0·69
$x(3)_4$	−0·094	+0·122	−0·066	+0·142			−0·957	−0·046	+0·995	−0·095			−0·50
$x(3)_5$	+0·614	+0·814	−0·439	+0·942					−0·995	+0·095	+0·007	−1·037	−0·06
$x(4)_2$	+1·293	+1·549	−1·783	+0·364									−0·08
$x(4)_3$	+1·341	−0·800	−0·945	−1·000									−0·04
$x(4)_4$	+0·897	−0·747	−0·630	−0·668	−0·224	+1·305							−0·55
$x(5)_1$			+0·066	+0·539			−1·849	+0·136	+1·783	−0·675			−1·60
$x(5)_2$			+2·150	+0·100					−1·783	+0·675	−0·367	−0·775	+1·25
$x(5)_3$	−1·781	−0·296	+1·710	−0·775							+0·367	+0·775	+0·82
$x(6)_1$					+1·061	−0·584							−0·22
$x(6)_2$	−1·750	+0·294	+1·231	+1·304	+0·683	−0·629							+0·07
$x(6)_3$	+1·750	−0·294	−1·231	−1·304	+0·138	+0·825	−0·862	+0·480					+0·23
$x(7)_1$	−0·939	−0·040	+0·021	−0·046			−1·050	−6·153	+2·007	+6·199			−2·13
$x(7)_2$	+0·939	+0·040	−1·870	+0·182			+0·892	−0·182					+0·22
$x(7)_3$					−0·862	+0·480	−0·210	−0·373					+0·25
$x(8)_1$	−1·033	+0·082	−0·044	+0·095					+0·424	−0·596	+0·571	+0·501	+0·58
$x(8)_2$	+1·033	−0·082	−1·739	+0·580					+0·788	−0·580			−1·28
$x(8)_3$			+1·783	−0·675			+2·007	+6·199	−3·790	−5·524			+3·90
$x(9)_1$	+0·419	−0·896	+0·851	−0·262							−0·374	+0·262	−0·35
$x(9)_2$			−0·367	−0·775					+0·571	+0·501	−0·204	+0·274	+0·51

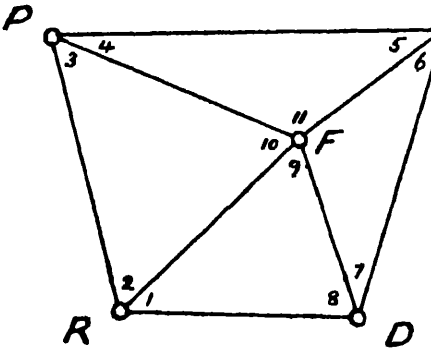
FIGURAL EQUATIONS—KROONSTAD TO WEPENER—*continued.*

Resulting Corrections.

$''$	$''$	$''$
$x(1)_1 = +0\cdot20$	$x(3)_5 = -0\cdot10$	$x(6)_3 = -0\cdot01$
$x(1)_2 = -0\cdot43$	$x(4)_2 = +0\cdot13$	$x(7)_1 = -0\cdot04$
$x(1)_3 = +0\cdot60$	$x(4)_3 = -0\cdot18$	$x(7)_2 = +0\cdot10$
$x(1)_4 = -0\cdot59$	$x(4)_4 = -0\cdot51$	$x(7)_3 = +0\cdot53$
$x(2)_1 = -0\cdot28$	$x(5)_1 = +0\cdot38$	$x(8)_1 = +0\cdot45$
$x(2)_2 = +0\cdot08$	$x(5)_2 = +0\cdot61$	$x(8)_2 = -0\cdot39$
$x(3)_1 = -0\cdot53$	$x(5)_3 = +0\cdot05$	$x(8)_3 = +0\cdot01$
$x(3)_3 = +0\cdot30$	$x(6)_1 = -0\cdot24$	$x(9)_1 = -0\cdot06$
$x(3)_4 = +0\cdot41$	$x(6)_2 = +0\cdot22$	$x(9)_2 = +0\cdot39$

HOPETOWN TO WEPENER.

Figure XI.



P ... Platkop.
L ... Lokshoek.
D ... Drie Baden.
R ... Luipers Rand.
F ... Fauresmith Hill.

Observed Angles.

	°	′	″		°	′	″
1 =	87	35	46·99	7 =	31	49	37·92
2 =	53	4	33·49	8 =	43	56	4·35
3 =	41	27	14·89	9 =	48	28	11·15
4 =	24	41	57·24	10 =	85	28	12·58
5 =	29	31	49·38	11 =	125	46	15·10
6 =	47	53	2·59				

Equations to be satisfied.

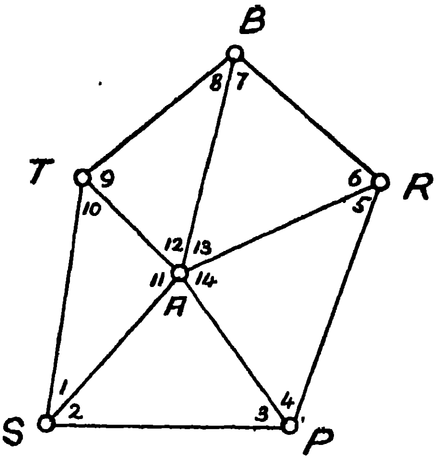
$$x_1 + x_8 + x_9 + 0\cdot74 = 0$$
$$x_2 + x_3 + x_{10} - 1\cdot00 = 0$$
$$x_4 + x_5 + x_{11} + 0\cdot09 = 0$$
$$x_6 + x_7 - x_9 - x_{10} - x_{11} - 0\cdot68 = 0$$
$$+0\cdot9x_1 - 15\cdot8x_2 + 23\cdot8x_3 - 45\cdot8x_4 + 37\cdot2x_5 - 19\cdot0x_6 + 34\cdot0x_7 - 21\cdot8x_8 - 36\cdot9 = 0$$

Resulting Corrections.

$''$	$''$	$''$	$''$
$x_1 = -0\cdot15$	$x_4 = -0\cdot17$	$x_7 = +0\cdot33$	$x_{10} = +0\cdot20$
$x_2 = +0\cdot31$	$x_5 = +0\cdot21$	$x_8 = -0\cdot26$	$x_{11} = -0\cdot13$
$x_3 = +0\cdot49$	$x_6 = +0\cdot09$	$x_9 = -0\cdot33$	

HOPETOWN TO KIMBERLEY.

Figure XII.



B ... Boshof Hill.
T ... Tarantal Kop.
R ... Rondefontein.
P ... Paardeberg.
S ... Scholtzkop.
A ... Aasvogel Kop.

Observed Angles.

	°	′	″		°	′	″
1 =	21	41	51·26	8 =	28	39	51·27
2 =	43	37	58·09	9 =	61	44	31·60
3 =	63	14	57·15	10 =	85	57	29·37
4 =	64	29	12·90	11 =	72	20	40·68
5 =	49	32	49·42	12 =	89	35	37·54
6 =	45	52	29·64	13 =	58	58	29·64
7 =	75	9	2·21	14 =	65	58	0·76

FIGURAL EQUATIONS—HOPETOWN TO KIMBERLEY—*continued.*

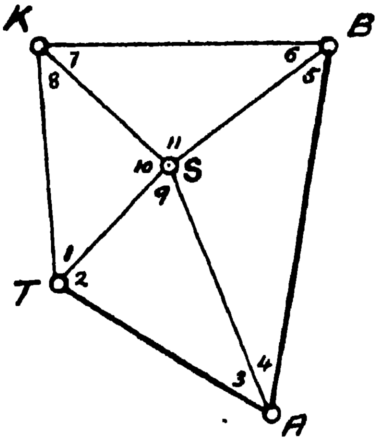
Equations to be satisfied.

$$x_1 + x_{10} + x_{11} + 0{\cdot}10 = 0$$
$$x_8 + x_9 + x_{12} - 0{\cdot}46 = 0$$
$$x_6 + x_7 + x_{13} - 0{\cdot}35 = 0$$
$$x_4 + x_5 + x_{14} + 0{\cdot}85 = 0$$
$$x_2 + x_3 - x_{11} - x_{12} - x_{13} - x_{14} - 0{\cdot}92 = 0$$
$$+ 52{\cdot}9\,x_1 - 22{\cdot}1\,x_2 + 10{\cdot}6\,x_3 - 10{\cdot}1\,x_4 + 17{\cdot}9\,x_5 - 20{\cdot}4\,x_6 + 5{\cdot}6\,x_7 - 38{\cdot}5\,x_8 + 11{\cdot}4\,x_9 - 1{\cdot}5\,x_{10} + 11{\cdot}1 = 0$$

Resulting Corrections.

$''$	$''$	$''$	$''$
$x_1 = +0{\cdot}03$	$x_5 = -0{\cdot}22$	$x_9 = +0{\cdot}21$	$x_{12} = +0{\cdot}03$
$x_2 = +0{\cdot}19$	$x_6 = +0{\cdot}18$	$x_{10} = +0{\cdot}03$	$x_{13} = -0{\cdot}01$
$x_3 = +0{\cdot}19$	$x_7 = +0{\cdot}18$	$x_{11} = -0{\cdot}16$	$x_{14} = -0{\cdot}41$
$x_4 = -0{\cdot}22$	$x_8 = +0{\cdot}22$		

Figure XIII.



K ... Kameelpan II.
B ... Boshof Hill.
A ... Aasvogel Kop.
T ... Tarantal Kop.
S ... Spion Kop.

Observed Angles.

	°	′	″		°	′	″
1 =	43	20	32·44	7 =	51	14	55·66
2 =	64	39	38·56	8 =	53	40	2·11
3 =	50	3	58·61	9 =	65	16	21·48
4 =	39	31	39·11	10 =	82	59	25·98
5 =	30	38	50·70	11 =	101	54	40·12
6 =	26	50	25·67				

Equations to be satisfied.

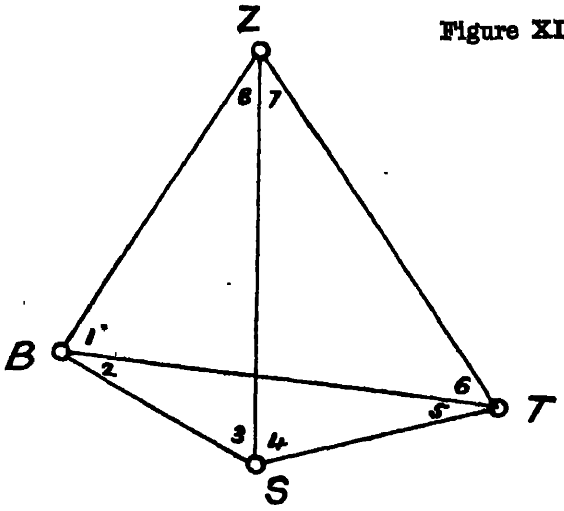
$$x_2 + x_3 + x_9 - 1{\cdot}71 = 0$$
$$x_4 + x_5 - x_9 - x_{10} - x_{11} + 1{\cdot}68 = 0$$
$$x_6 + x_7 + x_{11} + 1{\cdot}04 = 0$$
$$x_1 + x_8 + x_{10} + 0{\cdot}25 = 0$$
$$+ 22{\cdot}3\,x_1 - 10{\cdot}0\,x_2 + 17{\cdot}6\,x_3 - 25{\cdot}5\,x_4 + 35{\cdot}5\,x_5 - 41{\cdot}6\,x_6 + 16{\cdot}9\,x_7 - 15{\cdot}5\,x_8 - 22{\cdot}8 = 0$$
$$x_3 + x_4 - 0{\cdot}15 = 0$$
$$+ 10{\cdot}0\,x_2 - 35{\cdot}5\,x_5 - 2{\cdot}1\,x_9 + 7{\cdot}6\,x_{10} + 7{\cdot}6\,x_{11} - 33{\cdot}6 = 0$$

Resulting Corrections.

$''$	$''$	$''$	$''$
$x_1 = +0{\cdot}08$	$x_4 = -0{\cdot}57$	$x_7 = -0{\cdot}14$	$x_{10} = +0{\cdot}02$
$x_2 = +0{\cdot}83$	$x_5 = -0{\cdot}76$	$x_8 = -0{\cdot}35$	$x_{11} = -0{\cdot}13$
$x_3 = +0{\cdot}42$	$x_6 = -0{\cdot}77$	$x_9 = +0{\cdot}46$	

KIMBERLEY TO KROONSTAD.

Figure XIV.



Z ... Zoetvlei.
T ... Therons Kop.
S ... Schoongezicht.
B ... Biesie Pan.

Observed Angles.

	°	′	″
1 =	70	56	58·67
2 =	13	59	13·04
3 =	62	7	19·92
4 =	92	58	43·94
5 =	10	54	45·30
6 =	42	13	8·71
7 =	33	53	27·34
8 =	32	56	32·50

FIGURAL EQUATIONS—KIMBERLEY TO KROONSTAD—*continued.*

Equations to be satisfied.

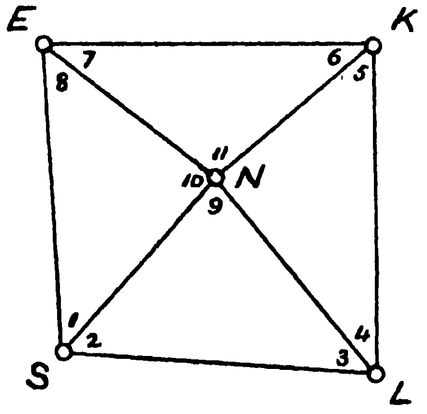
$$x_1 + x_2 + x_3 + x_8 + 0{\cdot}60 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 0{\cdot}20 = 0$$
$$x_2 + x_3 + x_4 + x_5 + 1{\cdot}03 = 0$$
$$+\,7{\cdot}3x_1 - 84{\cdot}5x_2 + 11{\cdot}1x_3 + 1{\cdot}1x_4 + 109{\cdot}2x_5 - 23{\cdot}2x_6 + 31{\cdot}4x_7 - 32{\cdot}5x_8 - 4{\cdot}3 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = +\,0{\cdot}02$	$x_3 = -\,0{\cdot}30$	$x_5 = -\,0{\cdot}19$	$x_7 = +\,0{\cdot}11$
$x_2 = -\,0{\cdot}32$	$x_4 = -\,0{\cdot}22$	$x_6 = +\,0{\cdot}10$	$x_8 = \quad 0{\cdot}00$

KIMBERLEY TO OTTOSHOOP.

Figure XV.



E ... Kopje Enkel.
K ... Kameelpan I.
L ... Langvallei.
S ... Schoonheid.
N ... Never Mind.

Observed Angles.

	°	′	″		°	′	″
1 =	27	5	52·81	7 =	49	39	56·19
2 =	61	15	38·52	8 =	52	8	12·81
3 =	55	11	1·68	9 =	63	33	20·37
4 =	13	16	37·87	10 =	100	45	56·15
5 =	31	33	48·62	11 =	60	31	9·32
6 =	69	48	53·88				

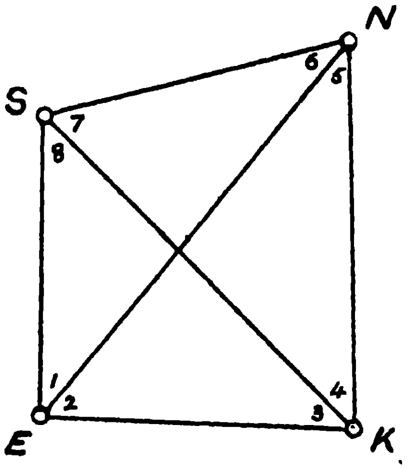
Equations to be satisfied.

$$x_2 + x_3 + x_9 - 0{\cdot}13 = 0$$
$$x_1 + x_8 + x_{10} + 0{\cdot}85 = 0$$
$$x_6 + x_7 + x_{11} - 1{\cdot}28 = 0$$
$$x_4 + x_5 - x_9 - x_{10} - x_{11} - 0{\cdot}11 = 0$$
$$+\,41{\cdot}2x_1 - 11{\cdot}5x_2 + 14{\cdot}7x_3 - 89{\cdot}2x_4 + 34{\cdot}8x_5 - 7{\cdot}8x_6 + 17{\cdot}9x_7 - 16{\cdot}4x_8 + 134{\cdot}2 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = -\,0{\cdot}68$	$x_4 = +\,0{\cdot}98$	$x_7 = +\,0{\cdot}24$	$x_{10} = -\,0{\cdot}16$
$x_2 = +\,0{\cdot}17$	$x_5 = -\,0{\cdot}44$	$x_8 = -\,0{\cdot}01$	$x_{11} = +\,0{\cdot}50$
$x_3 = -\,0{\cdot}13$	$x_6 = +\,0{\cdot}54$	$x_9 = +\,0{\cdot}09$	

Figure XVI.



S ... Smitskraal.
N ... Nooitgedacht II.
E ... Kopje Enkel.
K ... Kameelpan I.

Observed Angles.

	°	′	″		°	′	″
1 =	28	27	57·40	5 =	28	12	23·66
2 =	57	10	12·48	6 =	51	29	4·21
3 =	62	25	40·65	7 =	68	6	49·75
4 =	32	11	44·29	8 =	31	56	8·56

FIGURAL EQUATIONS—KIMBERLEY TO OTTOSHOOP—*continued.*

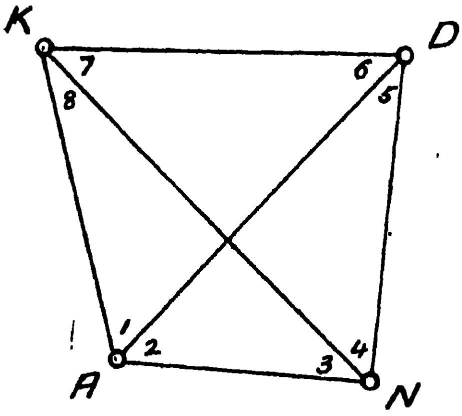
Equations to be satisfied.

$$x_1 + x_2 + x_3 + x_8 - 1{\cdot}31 = 0$$
$$x_1 + x_6 + x_7 + x_8 - 0{\cdot}43 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 1{\cdot}58 = 0$$
$$+ 38{\cdot}8x_1 - 13{\cdot}6x_2 + 11{\cdot}0x_3 - 33{\cdot}4x_4 + 39{\cdot}3x_5 - 16{\cdot}7x_6 + 8{\cdot}4x_7 - 33{\cdot}8x_8 + 63{\cdot}5 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = +0{\cdot}04$	$x_3 = +0{\cdot}09$	$x_5 = -0{\cdot}94$	$x_7 = -0{\cdot}35$
$x_2 = +0{\cdot}36$	$x_4 = -0{\cdot}16$	$x_6 = -0{\cdot}08$	$x_8 = +0{\cdot}82$

Figure XVII.



K ... Klipkuil.
D ... Doornhoek.
N ... Nooitgedacht II.
A ... Amsterdam.

Observed Angles.

	°	′	″		°	′	″
1 =	63	0	57·09	5 =	20	15	13·65
2 =	37	24	11·26	6 =	62	31	17·11
3 =	60	29	23·51	7 =	35	22	19·21
4 =	61	51	11·29	8 =	19	5	28·13

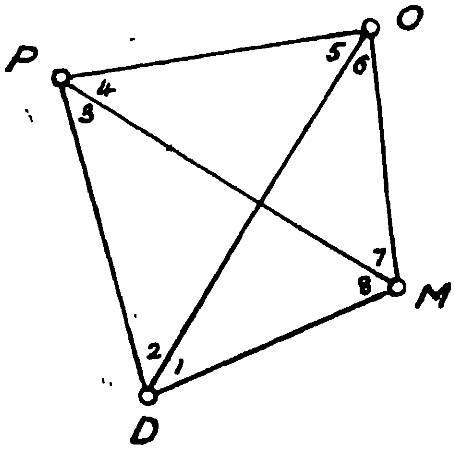
Equations to be satisfied.

$$x_1 + x_2 + x_3 + x_8 - 0{\cdot}53 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 0{\cdot}34 = 0$$
$$x_2 + x_3 + x_4 + x_5 - 0{\cdot}58 = 0$$
$$+ 10{\cdot}7x_1 - 27{\cdot}6x_2 + 11{\cdot}9x_3 - 11{\cdot}3x_4 + 57{\cdot}0x_5 - 11{\cdot}0x_6 + 29{\cdot}6x_7 - 60{\cdot}8x_8 + 5{\cdot}9 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = +0{\cdot}01$	$x_3 = +0{\cdot}26$	$x_5 = +0{\cdot}04$	$x_7 = -0{\cdot}20$
$x_2 = +0{\cdot}25$	$x_4 = +0{\cdot}08$	$x_6 = -0{\cdot}21$	$x_8 = +0{\cdot}01$

Figure XVIII.



P ... Makoeies Pan.
O ... Doornbult I.
M... Middelbult.
D ... Disselboompan.

Observed Angles.

	°	′	″		°	′	″
1 =	26	23	53·95	5 =	64	8	40·99
2 =	37	55	5·02	6 =	28	57	59·84
3 =	38	34	26·14	7 =	47	31	30·93
4 =	39	21	50·00	8 =	77	6	34·92

Equations to be satisfied.

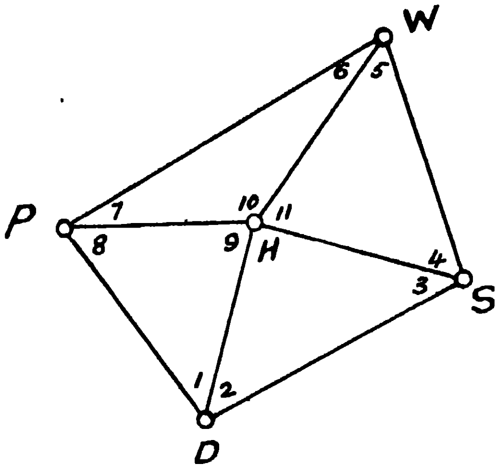
$$x_1 + x_2 + x_3 + x_8 - 1{\cdot}49 = 0$$
$$x_4 + x_5 + x_6 + x_7 + 0{\cdot}70 = 0$$
$$x_1 + x_6 + x_7 + x_8 - 1{\cdot}18 = 0$$
$$+ 42{\cdot}4x_1 - 27{\cdot}0x_2 + 26{\cdot}4x_3 - 25{\cdot}7x_4 + 10{\cdot}2x_5 - 38{\cdot}0x_6 + 19{\cdot}3x_7 - 4{\cdot}8x_8 - 2{\cdot}80 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = +0{\cdot}43$	$x_3 = +0{\cdot}07$	$x_5 = -0{\cdot}48$	$x_7 = -0{\cdot}09$
$x_2 = +0{\cdot}33$	$x_4 = -0{\cdot}31$	$x_6 = +0{\cdot}18$	$x_8 = +0{\cdot}66$

FIGURAL EQUATIONS—KIMBERLEY TO OTTOSHOOP—*continued.*

Figure XIX.



W ... Welvediend.
S ... Sypherpan.
H ... Houthaal Boomen.
D ... Doornbult I.
P ... De Paarl.

Observed Angles.

	°	′	″		°	′	″
1 =	27	4	29·16	7 =	24	42	42·28
2 =	60	26	26·62	8 =	67	33	26·60
3 =	59	25	12·52	9 =	85	22	5·65
4 =	32	27	58·61	10 =	134	43	11·27
5 =	67	45	39·00	11 =	79	46	21·21
6 =	20	34	5·64				

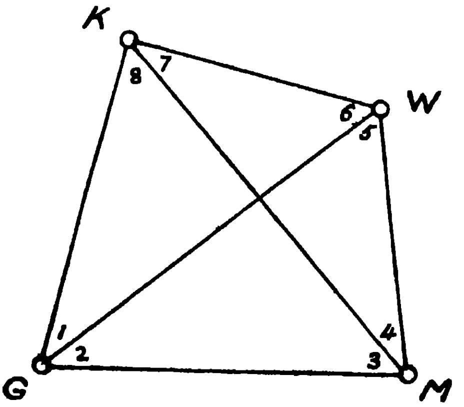
Equations to be satisfied.

$$x_1 + x_8 + x_9 + 0{\cdot}56 = 0$$
$$x_6 + x_7 + x_{10} - 1{\cdot}22 = 0$$
$$x_4 + x_5 + x_{11} - 2{\cdot}19 = 0$$
$$x_2 + x_3 - x_9 - x_{10} - x_{11} - 0{\cdot}51 = 0$$
$$+ 41{\cdot}2x_1 - 11{\cdot}9x_2 + 12{\cdot}4x_3 - 33{\cdot}1x_4 + 8{\cdot}6x_5 - 56{\cdot}1x_6 + 45{\cdot}7x_7 - 8{\cdot}7x_8 + 222{\cdot}7 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = -0{\cdot}82$	$x_4 = +1{\cdot}46$	$x_7 = -0{\cdot}68$	$x_{10} = +0{\cdot}08$
$x_2 = +0{\cdot}66$	$x_5 = +0{\cdot}44$	$x_8 = +0{\cdot}42$	$x_{11} = +0{\cdot}29$
$x_3 = +0{\cdot}06$	$x_6 = +1{\cdot}83$	$x_9 = -0{\cdot}16$	

Figure XX.



K ... Klippan.
W ... Witkop I.
M ... Malopos Oog.
G ... Grootfontein.

Observed Angles.

	°	′	″		°	′	″
1 =	43	47	58·50	5 =	39	2	47·34
2 =	25	7	22·05	6 =	64	19	12·64
3 =	67	55	26·02	7 =	28	43	36·17
4 =	47	54	23·26	8 =	43	9	12·18

Equations to be satisfied.

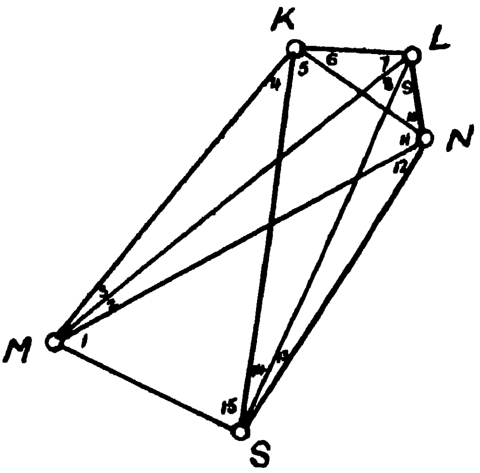
$$x_1 + x_2 + x_3 + x_8 - 2{\cdot}40 = 0$$
$$x_4 + x_5 + x_6 + x_7 - 1{\cdot}18 = 0$$
$$x_2 + x_3 + x_4 + x_5 - 1{\cdot}86 = 0$$
$$+ 21{\cdot}9x_1 - 44{\cdot}9x_2 + 8{\cdot}5x_3 - 19{\cdot}0x_4 + 25{\cdot}9x_5 - 10{\cdot}1x_6 + 38{\cdot}4x_7 - 22{\cdot}5x_8 + 96{\cdot}4 = 0$$

Resulting Corrections.

″	″	″	″
$x_1 = +0{\cdot}15$	$x_3 = +0{\cdot}17$	$x_5 = -0{\cdot}18$	$x_7 = -0{\cdot}18$
$x_2 = +1{\cdot}13$	$x_4 = +0{\cdot}69$	$x_6 = +0{\cdot}75$	$x_8 = +0{\cdot}95$

FIGURAL EQUATIONS—BELFAST TO LIMPOPO.

Figure XXI.



K ... Kameelkop.
L ... Loskop II.
N ... North end Houts River Base.
S ... South end Houts River Base.
M ... Matala.

Observed Angles.

	°	′	″		°	′	″
1 =	55	49	49·22	9 =	15	52	57·70
2 =	9	21	38·45	10 =	42	32	24·85
3 =	14	16	42·03	11 =	81	3	1·01
4 =	32	32	54·92	12 =	36	18	54·36
5 =	42	45	45·59	13 =	4	12	43·07
6 =	30	55	26·87	14 =	15	39	37·05
7 =	59	29	12·37	15 =	67	58	58·09
8 =	31	9	59·99				

Equations to be satisfied.

$$x_1 + x_{12} + x_{13} + x_{14} + x_{15} - 0{\cdot}31 = 0$$
$$x_3 + x_4 + x_5 + x_6 + x_7 + 0{\cdot}05 = 0$$
$$x_1 + x_2 + x_8 + x_{14} + x_{15} + 0{\cdot}18 = 0$$
$$x_1 + x_2 + x_3 + x_4 + x_{15} + 0{\cdot}16 = 0$$
$$x_2 + x_3 + x_4 + x_5 + x_{11} + 0{\cdot}25 = 0$$
$$x_6 + x_7 + x_8 + x_9 + x_{10} + 1{\cdot}01 = 0$$
$$+ 39{\cdot}2x_4 + 6{\cdot}2x_5 + 6{\cdot}2x_6 + 12{\cdot}4x_7 - 34{\cdot}9x_8 + 2{\cdot}8x_{14} - 6{\cdot}3\,x_{15} + 25{\cdot}40 = 0$$
$$+ 11{\cdot}8x_4 + 11{\cdot}8x_5 + 6{\cdot}2x_6 + 12{\cdot}4x_7 - 19{\cdot}6x_8 - 19{\cdot}6x_9 - 14{\cdot}0x_{10} - 17{\cdot}3x_{11} - 5{\cdot}10 = 0$$
$$+ 15{\cdot}3x_8 - 19{\cdot}6x_9 - 14{\cdot}0x_{10} - 14{\cdot}0x_{11} - 28{\cdot}6x_{12} + 0{\cdot}8x_{13} - 1{\cdot}5x_{14} - 1{\cdot}5x_{15} - 25{\cdot}60 = 0$$

Resulting Corrections.

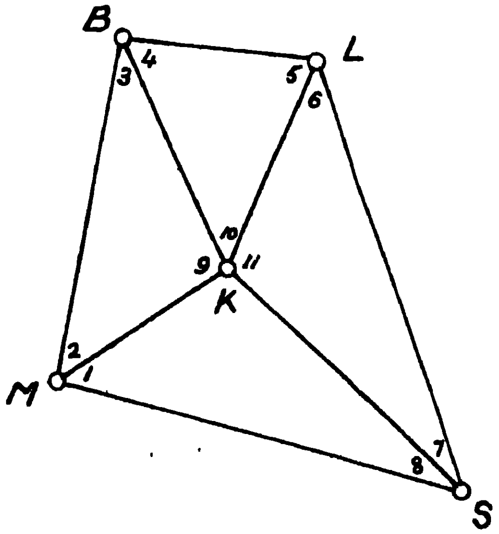
$x_1 = +0{\cdot}03''$
$x_2 = -0{\cdot}50''$
$x_3 = +0{\cdot}50''$
$x_4 = -0{\cdot}29''$

$x_5 = +0{\cdot}12''$
$x_6 = -0{\cdot}09''$
$x_7 = -0{\cdot}29''$
$x_8 = +0{\cdot}29''$

$x_9 = -0{\cdot}46''$
$x_{10} = -0{\cdot}46''$
$x_{11} = -0{\cdot}08''$
$x_{12} = -0{\cdot}15''$

$x_{13} = +0{\cdot}43''$
$x_{14} = -0{\cdot}10''$
$x_{15} = +0{\cdot}10''$

Figure XXII.



B ... Blaauwberg.
L ... Lejuma.
S ... Schnell's Kop,
M ... Matala.
K ... Loskop II.

Observed Angles.

		′	″
1 =	45	38	40·64
2 =	46	56	0·00
3 =	36	6	28·28
4 =	59	2	17·98
5 =	72	28	39·48
6 =	42	41	26·50
7 =	29	25	25·56
8 =	27	41	30·77
9 =	96	57	37·96
10 =	48	29	7·66
11 =	107	53	17·48

Equations to be satisfied

$$x_1 + x_8 - x_9 - x_{10} - x_{11} + 0{\cdot}18 = 0$$
$$x_2 + x_3 + x_9 - 0{\cdot}63 = 0$$
$$x_4 + x_5 + x_{10} - 0{\cdot}67 = 0$$
$$x_6 + x_7 + x_{11} + 0{\cdot}48 = 0$$
$$+ 20{\cdot}6x_1 - 19{\cdot}6x_2 + 28{\cdot}8x_3 - 12{\cdot}7x_4 + 6{\cdot}6x_5 - 22{\cdot}8x_6 + 37{\cdot}3x_7 - 40{\cdot}1x_8 + 6{\cdot}8 = 0$$

FIGURAL EQUATIONS—BELFAST TO LIMPOPO—*continued.*

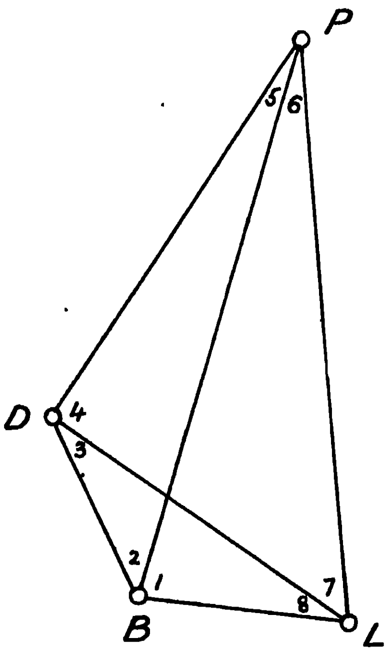
Resulting Corrections.

$x_1 = +0''{\cdot}02$
$x_2 = +0''{\cdot}24$
$x_3 = +0''{\cdot}20$
$x_4 = +0''{\cdot}24$

$x_5 = +0''{\cdot}28$
$x_6 = -0''{\cdot}18$
$x_7 = -0''{\cdot}17$
$x_8 = +0''{\cdot}06$

$x_9 = +0''{\cdot}19$
$x_{10} = +0''{\cdot}20$
$x_{11} = -0''{\cdot}18$

Figure XXIII.



P ... Pont.
L ... Lejuma.
B ... Blaauwberg.
D ... Dwarsberg.

Observed Angles.

	°	′	″
1 =	72	19	27·07
2 =	51	28	33·70
3 =	28	4	31·38
4 =	71	18	26·30
5 =	29	8	36·41
6 =	28	54	18·68
7 =	50	38	52·12
8 =	28	7	33·06

Equations to be satisfied.

$$x_1 + x_2 + x_3 + x_8 + 0{\cdot}88 = 0$$
$$x_4 + x_5 + x_6 + x_7 - 0{\cdot}65 = 0$$
$$x_1 + x_6 + x_7 + x_8 + 0{\cdot}76 = 0$$
$$+ 6{\cdot}7x_1 - 16{\cdot}8x_2 + 39{\cdot}5x_3 - 7{\cdot}1x_4 + 37{\cdot}7x_5 - 38{\cdot}2x_6 + 17{\cdot}2x_7 - 39{\cdot}4x_8 - 22{\cdot}30 = 0$$

Resulting Corrections.

$x_1 = -0''{\cdot}37$
$x_2 = -0''{\cdot}04$

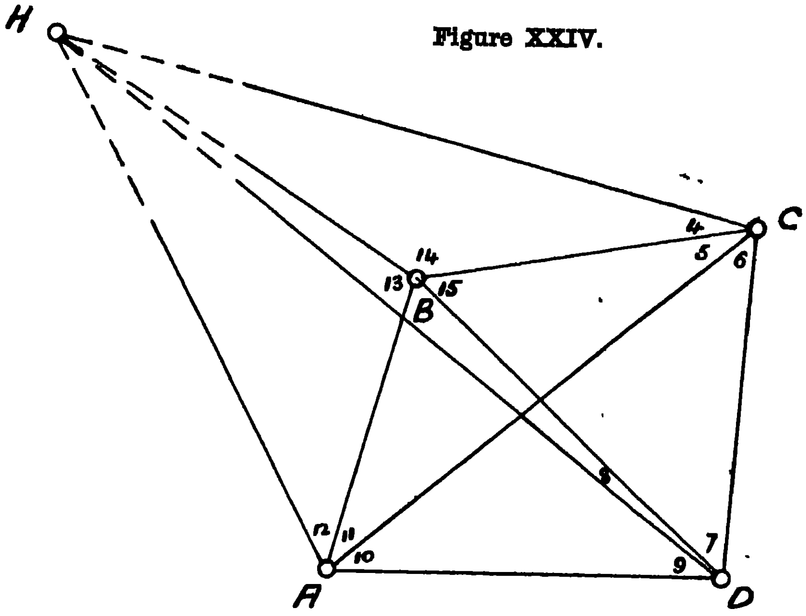
$x_3 = -0''{\cdot}04$
$x_4 = +0''{\cdot}33$

$x_5 = +0''{\cdot}33$
$x_6 = -0''{\cdot}01$

$x_7 = 0''{\cdot}00$
$x_8 = -0''{\cdot}38$

PRETORIA TO JOHANNESBURG.

Figure XXIV.



A ... Muckleneuk.
B ... Meintjes Kop.
C ... Koedoes Poort.
D ... Camp.
H ... Cable Hill.

Figural Equations—Pretoria to Johannesburg—*continued.*

Observed Angles.

	°	′	″		°	′	″
4 =	32	53	9·29	10 =	36	15	57·74
5 =	26	1	15·58	11 =	32	47	39·01
6 =	40	45	58·55	12 =	48	37	24·81
7 =	58	25	54·70	13 =	110	22	24·81
8 =	1	58	6·94	14 =	128	26	33·75
9 =	42	34	0·88	15 =	54	46	47·64

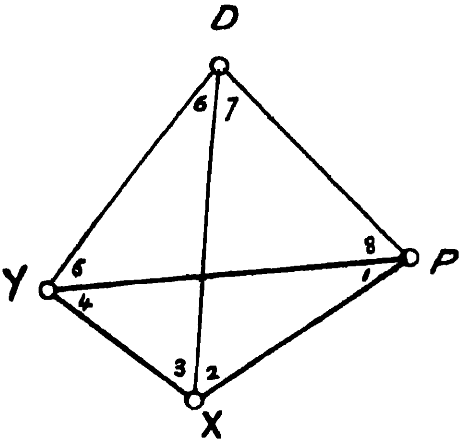
Equations to be satisfied.

$$x_6 + x_7 + x_8 + x_9 + x_{10} - 1{\cdot}24 = 0$$
$$x_5 + x_6 + x_7 + x_{15} - 3{\cdot}57 = 0$$
$$x_8 + x_9 + x_{10} + x_{11} - x_{13} - x_{14} - x_{15} - 1{\cdot}17 = 0$$
$$-34{\cdot}0x_5 + 9{\cdot}1x_6 - 12{\cdot}9x_7 + 21{\cdot}4x_8 + 21{\cdot}4x_9 - 8{\cdot}1x_{10} + 24{\cdot}6x_{11} + 269{\cdot}0 = 0$$
$$+612{\cdot}2x_8 - 22{\cdot}9x_9 - 11{\cdot}1x_{10} - 11{\cdot}1x_{11} - 29{\cdot}7x_{12} - 7{\cdot}8x_{13} - 374{\cdot}0x_{14}$$
$$-374{\cdot}0x_{15} - 2794{\cdot}0 = 0$$
$$-19{\cdot}9x_4 + 12{\cdot}7x_5 - 3{\cdot}2x_{11} + 15{\cdot}4x_{12} + 7{\cdot}8x_{13} - 16{\cdot}7x_{14} - 167{\cdot}0 = 0$$

Resulting Corrections.

″	″	″	″
$x_4 = -1{\cdot}48$	$x_7 = +1{\cdot}65$	$x_{10} = +0{\cdot}81$	$x_{13} = +0{\cdot}85$
$x_5 = +4{\cdot}31$	$x_8 = +1{\cdot}48$	$x_{11} = -3{\cdot}05$	$x_{14} = -3{\cdot}09$
$x_6 = -0{\cdot}53$	$x_9 = -2{\cdot}17$	$x_{12} = +0{\cdot}98$	$x_{15} = -1{\cdot}86$

Figure XXV.



D ... Daspoort.
P ... Cable Hill.
X ... Meintjes Kop.
Y ... Muckleneuk.

Observed Angles.

	°	′	″		°	′	″
2 =	43	37	50·58	6 =	16	15	25·22
3 =	66	44	34·34	7 =	35	26	12·15
5 =	48	22	30·54	8 =	79	55	49·63

Fixed Angles.

	°	′	″		°	′	″
1 =	21	0	9·61	4 =	48	37	25·29
2 + 3 =	110	22	25·16				

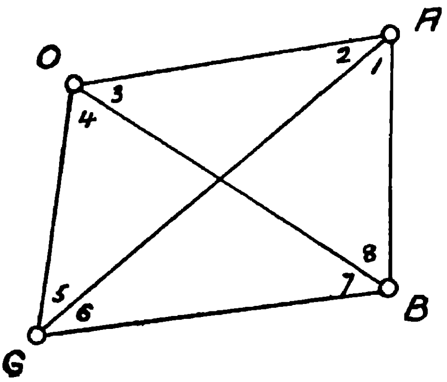
Equations to be satisfied.

$$x_2 + x_3 - 0{\cdot}24 = 0$$
$$x_3 + x_5 + x_6 - 4{\cdot}71 = 0$$
$$x_5 + x_6 + x_7 + x_8 - 2{\cdot}65 = 0$$
$$-22{\cdot}1x_2 + 9{\cdot}0x_3 + 18{\cdot}7x_5 - 72{\cdot}2x_6 + 29{\cdot}6x_7 - 3{\cdot}7x_8 + 23{\cdot}7 = 0$$

Resulting Corrections.

″	″
$x_2 = -1{\cdot}15$	$x_6 = +1{\cdot}31$
$x_3 = +1{\cdot}39$	$x_7 = -0{\cdot}21$
$x_5 = +2{\cdot}01$	$x_8 = -0{\cdot}46$

Figure XXVI.



A ... Driefontein.
B ... Klipfontein.
G ... Germiston.
O ... Observatory Hill (Johannesburg).

Observed Angles.

	°	′	″		°	′	″
1 =	50	34	41·34	5 =	50	27	45·22
2 =	20	45	56·19	6 =	49	1	30·08
3 =	51	51	51·32	7 =	23	36	18·37
4 =	56	54	25·78	8 =	56	47	30·16

FIGURAL EQUATIONS—PRETORIA TO JOHANNESBURG—*continued.*

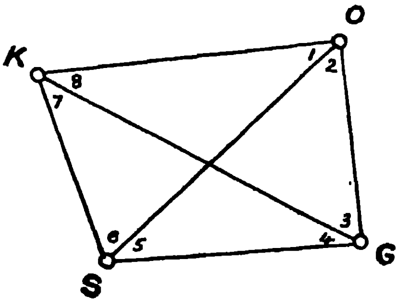
Equations to be satisfied.

$$x_2 + x_3 + x_4 + x_5 - 1{\cdot}74 = 0$$
$$x_4 + x_5 + x_6 + x_7 - 0{\cdot}80 = 0$$
$$x_1 + x_6 + x_7 + x_8 - 0{\cdot}07 = 0$$
$$+ 17{\cdot}8x_1 - 55{\cdot}6x_2 + 16{\cdot}5x_3 - 13{\cdot}7x_4 + 17{\cdot}4x_5 - 18{\cdot}3x_6 + 48{\cdot}2x_7 - 13{\cdot}8x_8 + 76{\cdot}0 = 0$$

Resulting Corrections.

"	"	"	"
$x_1 = - 0{\cdot}13$	$x_3 = + 0{\cdot}11$	$x_5 = + 0{\cdot}23$	$x_7 = - 0{\cdot}33$
$x_2 = + 0{\cdot}85$	$x_4 = + 0{\cdot}55$	$x_6 = + 0{\cdot}35$	$x_8 = + 0{\cdot}18$

Figure XXVII.



K ... Klipriviersberg.
O ... Observatory Hill (Johannesburg).
G ... Germiston.
S ... P_6 Beacon.

Observed Angles.

	°	′	″		°	′	″
1 =	52	57	53·94	5 =	39	0	7·30
2 =	36	18	31·80	6 =	56	57	39·58
3 =	54	21	30·62	7 =	33	42	20·93
4 =	50	19	53·27	8 =	36	22	1·48

Equations to be satisfied.

$$x_2 + x_3 + x_4 + x_5 + 2{\cdot}88 = 0$$
$$x_1 + x_6 + x_7 + x_8 - 4{\cdot}33 = 0$$
$$x_1 + x_2 + x_3 + x_8 - 2{\cdot}33 = 0$$
$$+ 16x_1 - 29x_2 + 15x_3 - 18x_4 + 26x_5 - 14x_6 + 32x_7 - 29x_8 + 14{\cdot}00 = 0$$

Resulting Corrections.

"	"	"	"
$x_1 = + 1{\cdot}46$	$x_3 = - 0{\cdot}34$	$x_5 = - 1{\cdot}14$	$x_7 = + 0{\cdot}66$
$x_2 = - 0{\cdot}30$	$x_4 = - 1{\cdot}10$	$x_6 = + 0{\cdot}70$	$x_8 = + 1{\cdot}51$

ADJUSTMENT OF CIRCUITS.

5. In adjusting the circuits of the present survey for geometrical consistency, the results of the survey of Cape Colony and Natal are utilised to the following extent (referring to "Report on the Geodetic Survey of South Africa," Vol. I., pp. 153-190):— Considerations controlling adjustment.

a. The closed circuits of Cape Colony are considered absolutely fixed.

b. The chain between Bedford and Newcastle, previously adjusted for closure on Natal base, is used for closure of Circuits I. and III. (see Diagram No. 2).

c. The chain between Hanover and Kimberley is used to close Circuits III. and IV.

In addition to *a* above, the present solution is controlled by the following considerations:—

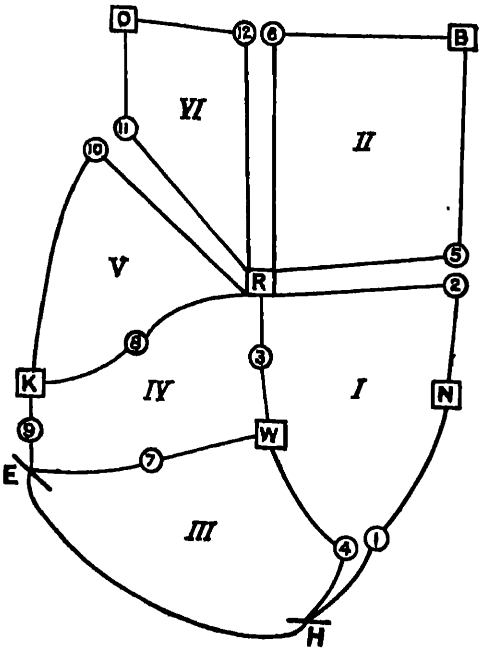
1. The measured lengths of all base lines, reduced to mean sea level, are considered fixed.
2. With the exception of angles measured on four arcs only, all angles of triangles forming parts of adjusted complex figures are considered fixed, and the circuit corrections fall on the solitary triangles.

3. In the chains measured on four arcs (triangles 76 to 131 in diagram), the angles of complex figures have equal weight with the angles of other chains.
4. The portion of Circuit III., between Breakfast Vlei—Hogsback and Besters Kop—Elandsberg II. (shown by the thick black lines in the Diagram), is absolutely fixed in length and direction.
5. The lines of base extensions are fixed in length.

In Diagram, No. 2, the triangles of which the angles receive circuit corrections are numbered 1 to 131. Those with weights unity are uncoloured, those with half-weight are coloured yellow.

Number of equations.

6. Since the fixed chain may be considered as a base, the conditions of the circuit solution depend on the closure of seven bases on each other, and on the closure of the six circuits in latitude, longitude and azimuth, or in X, Y, and bearing, if spheroidal co-ordinates are used. Starting with any one base, each of the others may be closed on through two independent chains; there are thus 2 (7 − 1) = 12 base equations, and the six circuits require 6 × 3 = 18 equations; or 30 in all.



Base equations.

7. In the accompanying diagram,

H = the line Hogsback to Breakfast Vlei in fixed chain.
E = the line Elandsberg II. to Besters Kop in fixed chain.
N = Natal Base.
B = Belfast Base.
R = Kroonstad Base.
W = Wepener Base.
O = Ottoshoop Base.
K = Kimberley Base.

The base equations are formed through the following chains :—

No.	1.—Fixed line H on Natal Base	through	H1N...	Equation	B_1
,,	2.—Natal Base on Kroonstad Base	,,	N2R...	,,	B_2
,,	3.—Kroonstad Base on Wepener Base	,,	R3W...	,,	B_3
,,	4.—Wepener Base on fixed line H	,,	W4H...	,,	B_4
,,	5.—Kroonstad Base on Belfast Base	,,	R5B...	,,	B_5
,,	6.—Belfast Base on Kroonstad Base	,,	B6R...	,,	B_6
,,	7.—Fixed line E on Wepener Base	,,	E7W...	,,	B_7
,,	8.—Kroonstad Base on Kimberley Base	,,	R8K...	,,	B_8
,,	9.—Kimberley Base on fixed line E	,,	K9E...	,,	B_9
,,	10.—Kimberley Base on Kroonstad Base	,,	K10R...	,,	B_{10}
,,	11.—Kroonstad Base on Ottoshop Base	,,	R11O...	,,	B_{11}
,,	12.—Ottoshoop Base on Kroonstad Base	,,	O12R ..	,,	B_{12}

Nos. 1 and 9 were adjusted for closure by the solution in the Cape-Natal Survey; they therefore enter into the equations with absolute terms = 0. The logarithmic discordances in closure for the other chains are :—

No. 2.	− 0·0000021	No. 7.	− 0·0000031
,, 3.	+ 0·0000030	,, 8.	0·0000000
,, 4.	− 0·0000039	,, 10.	+ 0·0000111
,, 5.	+ 0·0000060	,, 11.	− 0·0000210
,, 6.	− 0·0000070	,, 12.	+ 0·0000014

Circuit closures.

8. In the closures of circuits, the method of the Great Trigonometrical Survey of India (adopted in the circuit solution for Cape Colony) was not followed in the present solution. Instead, the adjustment was effected by

means of rectangular spheroidal co-ordinates. This method is fully described in paragraphs 41 to 52 of this report. The two methods would lead to identical results, but, by the first, six sets of differential coefficients have to be computed for each circuit, whereas, by the second, only two are required, and the coefficients of the y's and z's in the bearing equations are all ± 1. The labour of computation is thus considerably reduced by employing the second method.

Traverse lines of circuits (*See* Diagram No. 2).

9. Circuit I. begins and ends at 32 (Lubisi). The traverse line is 32 to 4, then in numerical order to 31, 32. The initial line, for bearing, is 32 to 52.

Circuit II. begins and ends at 18 (Salt Lake). The traverse line is 18, 33 . . . 46, 24, 47 . . . 51, 18. The initial line is 18 to 19.

Circuit III. is the completion of a circuit of which one branch is fixed. It begins at 0 (Breakfast Vlei), and ends at 63 (Elandsberg II.). The traverse line is 0 to 1 . . . 4, 52 . . . 55, 28, 56 . . . 63. The initial line is the fixed line in triangle 1, and the closing line the fixed line in triangle 66.

Circuit IV. is in two branches. Both branches begin at 64 (Machache), and end at 63 (Elandsberg II.). The traverse line of the lower branch is 64 to 28, 56 . . . 63. The line of traverse for the upper branch is 64, 65, 47, 24, 46, 66 . . . 79, 63. The initial and closing lines are 64 to 28 and 62 to 63.

Circuit V. begins and ends at 80 (Middelbult). The traverse line is 80 . . . 96, 73, 97 . . . 103, 66, 104 . . . 108, 80. The initial line is 80 to 119.

Circuit VI. begins and ends at 42 (Boshofsberg). The line of traverse is 42, 109 . . , 118, 81, 119 . . . 122, 67, 103, 123, 124, 24, 125 . . . 129, 42. The initial line is 42 to 43.

Origin of co-ordinates.

10. For Circuits I. and II. the origin of co-ordinates is the intersection of the 29th meridian and the 25th parallel. For Circuits III., IV., V., and VI. the origin is the intersection of the 26th meridian and the 25th parallel.

Errors of closure.

11. The following are the errors of closure in X, Y, and bearing, and their equivalents in latitude, longitude, and azimuth :—

Circuit.	Errors of Closure.						Equations.
	X.	Y.	Bearing.	Latitude.	Longitude.	Azimuth.	
	Feet.	Feet.	"	"	"	"	
I	−14·5	+ 3·8	+1·04	−0·143	−0·044	+1·06	X_1, Y_1, A_1
II	− 2·5	+ 6·1	+0·43	−0·025	−0·068	+0·46	X_2, Y_2, A_2
III	−23·0	+22·8	+0·72	−0·228	−0·259	+0·85	X_3, Y_3, A_3
IV	− 3·2	−10·0	+0·55	−0·032	+0·111	+0·49	X_4 Y_4, A_4
V	+ 2·6	− 3·0	+8·50	+0·026	+0·033	+8·49	X_5, Y_5, A_5
VI	−32·9	+ 0·2	−2·95	−0·326	−0·002	−2·95	X_6, Y_6, A_6

Error in computation of coefficients.

12. The coefficients of the y's and z's were computed independently by two computers, and the results compared. Unfortunately, in the coefficient of z_{56} in equation X_6, both computers omitted a term, with the result that the value −6·315 was used instead of the correct value −4·631. This error was not discovered until a recomputation was made.

Readjustment of chains.

13. In order to correct for the error above referred to, Circuits I., II., and III., and portions of the other circuits were considered fixed by the first solution, and the following chains readjusted :—

Chain *a* ... ... Triangles 56 to 64.
„ *b* ... ... „ 88 to 98, and 56.
„ *c* ... ... „ 76 to 88.

In addition to the error resulting from the erroneous coefficient, certain small errors of closure, due to the insufficiency of 7-figure logarithms, were introduced as absolute terms in the equations. The absolute terms in the 12 equations are:—

Chain.	Base.	X.	Y.	Bearing.
		Feet.	Feet.	"
a	0·00	0·00	−0·50	0·00
b	+0·12	−0·50	+0·70	0·00
c	−0·12	+0·50	+0·70	0·00

Arbitrary corrections.

14. After the readjustment of chains *a*, *b*, and *c*, the latitudes, longitudes and mutual azimuths of all stations in the circuits were computed, with the result that the following small errors of closure, entirely due to the insufficiency of 7-figure logarithms, were disclosed:—

Circuit.	Latitude.	Longitude.
	"	"
I	−0·001	+0·005
II	+0·003	−0·005
III	0·000	−0·002
IV	+0·004	−0·002
V	+0·004	−0·006
VI	0·000	−0·002

The corrections to remove these discordances were arbitrarily distributed.

Adjustment between Belfast and Houts River bases.

15. In the chain Belfast to Limpolo, the solitary triangles between the Belfast and Houts River base figures were adjusted as follows:—

The angles were first adjusted for $\frac{1}{3}$ error of triangle.

The equation is then:

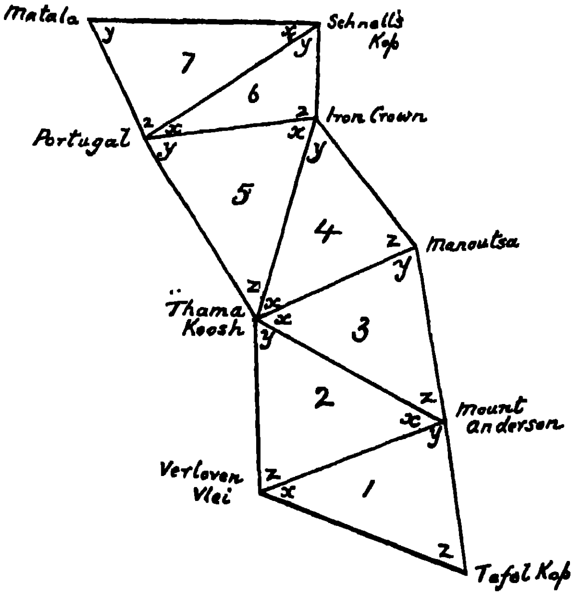
$$-7{\cdot}8y_1 + 18{\cdot}4z_1 - 15{\cdot}8y_2 + 8{\cdot}9z_2 - 11{\cdot}3y_3 + 12{\cdot}9z_3 - 18{\cdot}4y_4 + 12{\cdot}0z_4 - 16{\cdot}5y_5 + 20{\cdot}4z_5 - 12{\cdot}7y_6 - 6{\cdot}0z_6 - 12{\cdot}4y_7 + 0{\cdot}3z_7 - 75{\cdot}8 = 0,$$

whence

$$2544\,B - 75{\cdot}8 = 0$$
$$B = +\,0{\cdot}02979.$$

The resulting corrections are:—

Δ	*x*	*y*	*z*
	"	"	"
1	−0·32	−0·23	+0·55
2	+0·21	−0·47	+0·26
3	−0·04	−0·34	+0·38
4	+0·19	−0·55	+0·36
5	−0·12	−0·49	+0·61
6	+0·56	−0·38	−0·18
7	+0·36	−0·37	+0·01



Data and results.

16. The data and results of the solution are given in the following tables:—

Table C gives, for every circuit, the co-ordinates of stations in the line of traverse, and the bearing of the forward station, before adjustment.

Table D gives the value of P and Q (*i.e.* the summations of the differential factors) for every station in the traverse.

Table E gives the values of the coefficients of *y* and *z*, and the absolute terms in each equation.

Following Table E are the normal equations and the values of the indeterminate factors.

Table F gives the resulting corrections to the angles.

Table G gives the values of P and Q for the re-adjustment of chains *a*, *b*, and *c*.

Table H gives the coefficients of *y* and *z* for the readjustment.

Following Table H are the normal equations, and values of the factors.

Table J gives the resulting corrections.

Table K shows the magnitude and distribution of the arbitrary corrections.

Table L gives the co-ordinates of stations in the circuits after the final adjustment.

Following Table L are given the non-circuit equations, or re-adjustment of figures disturbed by the circuit solution.

Table C.

CO-ORDINATES OF STATIONS ON THE LINE OF TRAVERSE.

CIRCUIT I. Origin ϕ_0 25°, L_0 — 29°.

Station A.			Station B.			
Number in Traverse.	Co-ordinates.		Number in Traverse.	Bearing.		
	Y.	X.				
	Eng. Feet.	Eng. Feet.		°	′	″
32	+468020·7	+2466615·4	4	281	29	31·98
4	+302170·1	+2500837·7	5	223	0	16·82
5	+191804·9	+2382005·0	6	243	43	38·25
6	+ 55913·4	+2314924·4	7	208	50	15·64
7	+ 14452·6	+2239625·3	8	210	49	29·83
8	— 64734·2	+2106918·2	9	209	54	42·90
9	—182048·1	+1989907·5	10	247	20	3·04
10	—274920·2	+1980287·9	11	191	16	17·07
11	—292587·2	+1841572·0	12	220	26	7·44
12	—377062·6	+1742417·9	13	196	49	51·17
13	—398492·8	+1671555·5	14	161	13	38·74
14	—351853·9	+1584344·4	15	187	10	45·86
15	—866884·8	+1418925·2	16	191	2	25·15
16	—889008·5	+1302922·4	17	207	57	57·87
17	—457015·6	+1174790·9	18	184	59	59·61
18	—843881·9	+1061149·1	19	152	50	29·57
19	—269188·5	+ 916529·7	20	100	2	19·11
20	—138940·8	+ 898472·6	21	69	14	22·78
21	— 17868·8	+ 939556·9	22	75	28	45·60
22	+184222·7	+ 978819·9	23	95	29	11·81
23	+284698·1	+ 964365·4	24	94	6	49·47
24	+404156·4	+ 955772·2	25	22	48	20·78
25	+450858·1	+1065690·0	26	86	34	1·11
26	+497887·5	+1129786·6	27	0	17	34·71
27	+499249·9	+1404743·7	28	16	48	15·60
28	+552487·9	+1581150·8	29	10	5	41·10
29	+614546·0	+1930828·0	30	338	47	10·95
30	+542114·9	+2077458·8	31	348	45	39·59
31	+488669·0	+2278091·7	32	355	15	38·06
32	+468024·5	+2466600·9	4	281	29	33·02

Table C—*continued.*

Co-ordinates of Stations on the Line of Traverse—*continued.*

Circuit II. Origin ϕ_0 25°, L_0 — 29°.

Station A.			Station B.			
Number in Traverse.	Co-ordinates.		Number in Traverse.	Bearing.		
	Y.	X.				
	Eng. Feet.	Eng. Feet.		°	′	″
18	−343881·9	+1061149·1	33	210	0	39·26
33	−432087·4	+ 907610·7	34	200	35	40·79
34	−470571·4	+ 805028·5	35	165	49	38·96
35	−428491·7	+ 688412·5	36	198	5	44·50
36	−489811·8	+ 450650·4	37	204	25	22·20
37	−570485·6	+ 272996·0	38	125	21	44·39
38	−360898·8	+ 124282·6	39	188	32	54·08
39	−251598·0	+ 20881·2	40	109	28	33·16
40	− 76818·4	− 41818·3	41	91	16	34·55
41	+276600·8	− 49181·2	42	90	38	1·58
42	+452408·6	− 51126·8	43	4	46	36·01
43	+482949·8	+ 315814·6	44	11	54	34·70
44	+526446·6	+ 521780·4	45	347	7	6·62
45	+495437·2	+ 657816·6	46	25	40	55·08
46	+552577·8	+ 776199·3	24	320	25	27·21
24	+404160·6	+ 955768·4	47	336	42	37·36
47	+328687·3	+1131008·5	48	284	59	36·94
48	+160841·6	+1176048·1	49	237	23	6·47
49	− 8857·8	+1067780·7	50	286	41	48·28
50	−111868·9	+1000105·9	51	286	36	39·64
51	−224885·6	+1088808·2	18	282	55	56·85
18	−343875·8	+1061146·6	33	210	0	39·69

Circuit III. Origin ϕ_0 25°, L_0 — 26°.

	Eng. Feet.	Eng. Feet.		°	′	″
0	−291721·4	+2943579·1	1	258	24	15·10
1	−454084·1	+2910255·6	2	209	29	3·21
2	−580897·2	+2774340·1	3	178	59	36·69
3	−527865·0	+2602702·5	4	226	0	26·23
4	−629157·6	+2504860·3	52	178	25	11·36
52	−628858·4	+2295504·4	53	176	59	35·08
53	−619753·5	+2227006·7	54	168	12	7·07
54	−551459·9	+2000816·5	55	191	55	54·11
55	−609765·1	+1724541·9	28	125	8	55·25
28	−403425·4	+1579246·4	56	80	30	32·27
56	−325612·0	+1711808·1	57	90	36	55·11
57	−126788·7	+1709167·7	58	94	10	51·95
58	+181797·6	+1690264·6	59	65	50	47·80
59	+209241·2	+1724995·1	60	120	4	30·08
60	+295877·0	+1674819·4	61	90	44	40·91
61	+452812·2	+1672785·6	62	74	48	57·61
62	+551688·7	+1699920·5	63	61	29	15·10
63	+683379·6	+1771499·7	Besters Kop	296	7	2·88
	Fixed.	Fixed.		Fixed.		
63	+683356·8	+1771522·7	Besters Kop	296	7	1·61

Table C—*continued.*

CO-ORDINATES OF STATIONS ON THE LINE OF TRAVERSE—*continued.*

CIRCUIT IV, Lower Branch. Origin ϕ_0 25°, L_0 − 26°.

Station A.			Station B.			
Number in Traverse.	Co-ordinates.		Number in Traverse.	Bearing.		
	Y.	X.				
	Eng. Feet.	Eng. Feet.		°	′	″
64	−603944·5	+1589162·3	28	92	49	50·00
28	−403425·4	+1579246·4	56	30	30	32·27
56	−325612·0	+1711803·1	57	90	36	55·11
57	−126783·7	+1709167·7	58	94	10	51·95
58	+131797·6	+1690264·6	59	65	50	47·80
59	+209241·2	+1724995·2	60	120	4	30·03
60	+295877·0	+1674819·4	61	90	44	40·91
61	+452812·2	+1672785·6	62	74	43	57·61
62	+551688·7	+1699920·5	63	61	29	15·10
63	+683879·6	+1771499·7	62	241	28	54·21

CIRCUIT IV, Upper Branch. Origin ϕ_0 25°, L_0 − 26°.

	Eng. Feet.	Eng. Feet.		°	′	″
64	−608944·6	+1589162·3	65	187	56	3·09
65	−646782·4	+1281524·8	47	176	47	0·98
47	−638482·2	+1184925·1	24	158	6	54·93
24	−567320·1	+ 957757·4	46	141	48	13·66
46	−428266·2	+ 774661·9	66	19	50	41·00
66	−384404·7	+ 882343·0	67	81	54	12·38
67	−195185·9	+ 909262·0	68	32	22	43·77
68	−116795·8	+1082888·0	69	29	5	7·96
69	− 40936·5	+1169252·8	70	86	40	45·60
70	+ 65692·4	+1175489·6	71	76	6	57·42
71	+170274·3	+1201290·8	72	46	19	47·36
72	+265767·9	+1292460·4	73	67	58	45·90
73	+352133·7	+1327541·8	74	61	24	41·50
74	+415848·2	+1362270·6	75	80	58	28·14
75	+464986·9	+1370079·0	76	70	52	10·74
76	+570659·2	+1406747·8	77	36	36	59·46
77	+663864·7	+1582251·1	78	310	16	0·71
78	+587809·2	+1596698·0	79	42	9	14·04
79	+623268·9	+1685886·4	63	23	55	6·45
63	+683869·6	+1771496·5	62	241	28	54·76

CIRCUIT V. Origin ϕ_0 25°, L_0 − 26°.

	Eng. Feet.	Eng. Feet.		°	′	″
80	− 24401·4	+ 541427·4	81	54	59	2·90
81	+ 30960·3	+ 580214·9	82	40	59	0·67
82	+ 81439·9	+ 638819·8	83	70	3	20·33
83	+116275·1	+ 650960·2	84	71	23	31·38
84	+166539·5	+ 667884·4	85	46	6	4·08
85	+193731·8	+ 694052·4	86	31	18	43·62
86	+241523·0	+ 772625·2	87	53	26	59·65
87	+317356·5	+ 828848·8	88	351	59	20·75
88	+306627·0	+ 905081·1	89	356	47	12·86
89	+305904·0	+ 917959·7	90	347	38	57·54
90	+295128·0	+ 966857·3	91	355	0	10·06
91	+289069·7	+1036074·2	92	349	57	44·64

Table C—*concluded.*

CO-ORDINATES OF STATIONS ON THE LINE OF TRAVERSE—*continued.*

CIRCUIT V.—*continued.*

Station A.			Station B.	
Number in Traverse.	Co-ordinates.		Number in Traverse.	Bearing.
	Y.	X.		
	Eng. Feet.	Eng. Feet.		° ′ ″
92	+277780·3	+1100135·5	93	339 19 28·13
93	+260046·9	+1146995·6	94	53 48 14·43
94	+305868·4	+1180629·6	95	14 34 57·26
95	+316290·5	+1220716·6	96	16 25 3·31
96	+335020·3	+1284296·2	73	21 38 14·74
73	+352168·7	+1327533·5	97	309 38 19·63
97	+317783·6	+1356062·9	98	278 12 22·31
98	+208296·4	+1371845·8	99	218 27 40·91
99	+151520·8	+1300381·1	100	258 29 17·65
100	− 27209·2	+1268978·4	101	241 14 38·42
101	−128593·6	+1208342·3	102	269 7 36·40
102	−251146·3	+1206474·2	103	196 40 38·13
103	−301823·9	+1037251·3	66	208 4 0·36
66	−384392·5	+ 882355·0	104	115 11 49·40
104	−275158·4	+ 830956·5	105	187 35 56·68
105	−288754·9	+ 729007·9	106	124 42 59·89
106	−221966·7	+ 682730·8	107	101 14 39·94
107	−149820·1	+ 668386·9	108	133 28 50·93
108	− 91300·6	+ 613052·7	80	136 57 16·08
80	− 24404·4	+ 541430·0	81	54 59 11·40

CIRCUIT VI. Origin ϕ_0 25°, L_0 — 26°.

	Eng. Feet.	Eng. Feet.		° ′ ″
42	−542888·3	− 50135·6	109	58 52 38·10
109	−352154·0	+ 64784·4	110	38 52 46·77
110	−235977·3	+ 208817·6	111	109 6 27·21
111	− 72991·3	+ 152355·1	112	58 3 15·85
112	+ 2888·7	+ 209384·0	113	48 37 48·06
113	+ 49527·7	+ 258361·0	114	356 13 20·96
114	+ 44112·7	+ 340869·5	115	349 52 3·63
115	+ 38094·6	+ 374044·4	116	306 7 24·98
116	+ 11030·6	+ 393796·9	117	34 15 51·90
117	+ 29225·4	+ 420505·0	118	18 48 8·60
118	+ 48097·2	+ 475938·6	81	350 40 5·06
81	+ 30960·3	+ 580214·9	119	328 14 18·66
119	− 13166·3	+ 639282·8	120	304 35 41·18
120	− 74856·5	+ 681832·0	121	307 31 39·62
121	−144708·7	+ 735486·5	122	316 20 22·35
122	−195888·6	+ 789114·9	67	0 19 50·14
67	−195187·1	+ 909267·8	103	320 11 16·91
103	−301848·2	+1037250·1	123	248 28 53·20
123	−380604·4	+ 997802·0	124	236 59 39·89
124	−442288·1	+ 957729·4	24	270 0 54·64
24	−567335·0	+ 957762·5	125	229 12 51·56
125	−651577·3	+ 885045·0	126	184 30 35·67
126	−658145·3	+ 801667·4	127	193 31 7·56
127	−715599·1	+ 562375·2	128	164 47 26·34
128	−681150·5	+ 435645·2	129	190 30 58·36
129	−714282·2	+ 256928·6	42	150 45 51·49
42	−542888·1	− 50168·3	109	58 52 35·15

Table D.

VALUES OF P AND Q USED IN COMPUTATIONS.

CIRCUIT I.

No. in Traverse.	P.	Q.
32	0·0000	0·0000
4	−0·1653	+0·8042
5	+0·4084	+1·3898
6	+0·7837	+1·9982
7	+1·0988	+2·1992
8	+1·7422	+2·5831
9	+2·3094	+2·9094
10	+2·5987	+3·6020
11	+3·0285	+3·6877
12	+3·5091	+4·0973
13	+3·8526	+4·2012
14	+4·5177	+3·9752
15	+5·0772	+4·0457
16	+5·6395	+4·1554
17	+6·2605	+4·4852
18	+6·8114	+3·9848
19	+7·5124	+3·5747
20	+7·6242	+2·9483
21	+7·4007	+2·3540
22	+7·2104	+1·6192
23	+7·2805	+0·8897
24	+7·3222	+0·3105
25	+6·7895	+0·0864
26	+6·4788	−0·1440
27	+5·1462	−0·1508
28	+4·2913	−0·4089
29	+2·5993	−0·7101
30	+1·8862	−0·3590
31	+0·9137	−0·0758

CIRCUIT II.

No. in Traverse.	P.	Q.
18	0·0000	0·0000
33	+0·7439	+0·4803
34	+1·2412	+0·6171
35	+2·0488	+0·4132
36	+2·9588	+0·7106
37	+3·8198	+1·1015
38	+4·5405	+0·0856
39	+5·0442	−0·4443
40	+5·3488	−1·2941
41	+5·3814	−3·0051
42	+5·3908	−3·8574
43	+3·6147	−4·0059
44	+2·6143	−4·2169
45	+1·9572	−4·0666
46	+1·3811	−4·3487
24	+0·5107	−3·6243
47	−0·3892	−3·2584
48	−0·5571	−2·4447
49	−0·0822	−1·6243
50	+0·2959	−1·1248
51	+0·1325	−0·5772

CIRCUIT III.

No. in Traverse.	P.	Q.
0	−5·6804	+4·7265
1	−5·5189	+5·5186
2	−4·8601	+5·8860

Circuit III (*cont.*).

No. in Traverse.	P.	Q.
3	−4·0283	+5·8714
4	−3·5541	+6·3625
52	−2·5396	+6·3845
53	−2·2076	+6·3171
54	−1·1114	+5·9862
55	+0·2274	+6·2691
28	+0·9817	+5·2688
56	+0·2916	+4·8916
57	+0·3020	+3·9278
58	+0·3986	+2·6742
59	+0·2252	+2·2987
60	+0·4684	+1·8786
61	+0·4783	+1·1202
62	+0·3468	+0·6884
63	0·0000	0·0000

CIRCUIT IV.

Lower Branch.

No. in Traverse.	P.	Q.
64	+0·8842	+6·2408
28	+0·9817	+5·2688
56	+0·2916	+4·8916
57	+0·3020	+3·9278
58	+0·3986	+2·6742
59	+0·2252	+2·2987
60	+0·4684	+1·8786
61	+0·4783	+1·1202
62	+0·3468	+0·6884
63	0·0000	0·0000

CIRCUIT IV.

Upper Branch.

No. in Traverse.	P.	Q.
64	+0·8842	+6·2408
65	+2·3749	+6·4481
47	+3·0858	+6·4082
24	+3·9439	+6·0638
46	+4·3315	+5·3651
66	+4·3096	+5·1767
67	+4·1791	+4·2594
68	+3·5797	+3·8794
69	+2·9185	+3·5116
70	+2·8885	+2·9947
71	+2·7632	+2·4877
72	+2·3212	+2·0247
73	+2·1512	+1·6060
74	+1·9828	+1·2971
75	+1·9450	+1·0589
76	+1·7673	+0·5466
77	+1·1592	+0·0946
78	+0·8469	+0·4688
79	+0·6570	+0·2914
63	0·0000	0·0000

CIRCUIT V.

No. in Traverse.	P.	Q.
80	0·0000	0·0000
81	−0·1882	−0·2688

Circuit V (*cont.*).

No. in Traverse.	P.	Q
82	−0·4699	−0·5135
83	−0·5812	−0·6824
84	−0·6138	−0·9260
85	−0·7402	−1·0578
86	−1·1211	−1·2895
87	−1·3937	−1·6571
88	−1·7633	−1·6051
89	−1·8257	−1·6016
90	−2·0627	−1·5493
91	−2·3982	−1·5200
92	−2·7088	−1·4650
93	−2·9360	−1·3793
94	−3·0990	−1·6014
95	−3·2988	−1·6520
96	−3·6015	−1·7428
73	−3·8111	−1·8259
97	−3·9494	−1·6590
98	−4·0259	−1·1284
99	−3·6794	−0·8532
100	−3·5029	+0·0134
101	−3·2331	+0·5049
102	−3·2240	+1·0990
103	−2·4036	+1·3448
66	−1·6528	+1·7451
104	−1·4036	+1·2156
105	−0·9094	+1·2815
106	−0·6850	+0·9577
107	−0·6155	+0·6080
108	−0·3472	+0·3243

CIRCUIT VI.

No. in Traverse.	P.	Q
42	0·0000	0·0000
109	−0·5545	−0·9230
110	−1·2530	−1·4862
111	−0·9798	−2·2764
112	−1·2558	−2·6440
113	−1·4932	−2·8703
114	−1·8908	−2·8440
115	−2·0540	−2·8148
116	−2·1498	−2·6836
117	−2·2793	−2·7718
118	−2·5480	−2·8633
81	−3·0586	−2·7802
119	−3·3400	−2·5663
120	−3·5463	−2·2673
121	−3·8064	−1·9286
122	−4·0664	−1·6806
67	−4·6489	−1·6840
103	−5·2693	−1·1669
123	−5·0781	−0·7850
124	−4·8839	−0·4860
24	−4·8841	+0·1203
125	−4·5817	+0·5287
126	−4·1277	+0·5606
127	−2·9684	+0·8393
128	−2·3543	+0·6724
129	−1·4883	+0·8331

Table E.

SOLUTION OF CIRCUIT EQUATIONS.

VALUES OF THE COEFFICIENTS AND ABSOLUTE TERMS.

EQUATION B_1.

Δ.	y.	z.
1	+0·347	−0·616
2	+0·218	−0·316
3	+0·665	−0·268
4	+1·126	−0·639
5	+0·344	−0·648
6	+0·574	−1·017
7	+0·960	−0·112
8	+0·588	−0·637
9	+0·778	−0·505
10	+0·251	−0·534
11	+0·292	−0·656
12	+0·409	−0·900
13	+0·250	−0·335
14	+1·184	−0·304
15	+0·344	−0·911

Absolute Term 0·00.

EQUATION B_2.

Δ.	y.	z.
16	+0·338	−0·728
17	+0·122	−0·654
18	+0·864	−0·433
19	+0·513	−0·389
20	+0·744	−0·828
21	+0·784	−0·475
22	+0·842	−0·898
23	+0·198	−0·881
24	+1·108	+0·037
25	+0·707	−0·739
26	+0·443	−0·763
27	+0·335	−0·950
28	+0·475	−0·848
29	+0·038	−0·720
30	+1·011	+0·004

Absolute Term −1·00.

EQUATION B_3.

Δ.	y.	z.
31	−0·146	−0·730
32	−0·089	−0·960
33	+0·807	−0·704
34	+0·881	−0·979
35	+0·676	−0·276

Absolute Term +1·42.

EQUATION B_4.

Δ.	y.	z.
1	−0·347	+0·616
2	−0·218	+0·316
3	−0·665	+0·268
4	−1·126	+0·639
5	−0·344	+0·648

Equation B_4 (*cont.*).

Δ.	y.	z.
6	+0·262	+1·279
36	+1·110	−0·121
37	+0·946	−0·030
38	+0·169	−1·255
39	+1·165	−0·040
40	+0·249	−0·158
41	+0·162	−0·962

Absolute Term −1·85.

EQUATION B_5.

Δ.	y.	z.
22	−0·082	−0·140
23	−0·198	+0·881
24	−1·108	−0·037
25	−0·707	+0·739
26	−0·443	+0·763
27	−0·335	+0·950
28	−0·475	+0·848
29	−0·038	+0·720
30	−1·011	−0·004
42	+0·645	−0·658
43	+0·527	+0·134

Absolute Term +2·85.

EQUATION B_6.

Δ.	y.	z.
44	+0·698	+0·015
45	+0·344	−1·027
46	+0·729	−0·138
47	+0·020	−0·604
48	+1·413	−0·396
49	+0·489	−0·486
50	+0·381	−0·672
51	+0·096	−0·451
52	+0·376	−0·188
53	+0·718	−0·488
54	+0·222	−0·374
55	−0·036	−0·390

Absolute Term −3·32.

EQUATION B_7.

Δ.	y.	z.
66	−1·250	−0·710
67	+0·060	−0·962
68	+0·628	−0·017
69	+0·269	−0·744
70	+1·185	−0·106
71	+0·096	−1·055
72	+0·788	−0·652
73	+0·590	−1·074

Absolute Term −1·47.

EQUATION B_8.

Δ	y.	z.
56	+0·731	−0·618
57	+0·321	−0·602
58	+0·274	−0·715
59	+0·759	−0·753
60	+0·204	−0·935
61	+0·697	−1·035
62	+1·125	+0·055
63	+0·648	−0·912
64	+0·687	−0·280

Absolute Term 0·00.

EQUATION B_9.

Δ	y.	z.
65	+0·454	−0·637
66	+0·540	−0·404

Absolute Term 0·00.

EQUATION B_{10}.

Δ	y.	z.
56	+0·407	+1·025
88*	+0·917	+0·887
89*	+0·851	−0·455
90*	+0·749	−0·387
91*	+0·576	−0·738
92*	+0·910	−0·654
93*	+0·121	−0·980
94*	+0·164	−0·039
95*	+0·882	−0·412
96*	+0·854	−0·368
97*	+0·520	−0·990
98*	−0·372	−1·523
99*	−0·038	+0·459
100*	−0·804	+0·414
101*	−1·039	+0·186
102*	−0·089	+0·680
103*	−0·622	+0·251
104*	+0·133	+0·721
105*	−0·799	+0·292
106*	−0·158	+0·505
107*	+0·356	+0·471
108*	+0·024	+0·645
109*	−0·387	+0·970
110*	−1·142	−0·086
111*	−0·280	+0·040
112*	+0·064	+1·170
113*	−0·872	+0·485
114	−0·127	+0·587
115	−2·887	−0·184
116*	−0·098	+0·350
117	−0·182	+1·588
118	−1·604	+0·076
119	−0·368	+0·565
120	−0·778	+1·954
121	−0·497	+0·695

* Half weight.

Table E—*continued.*

Values of the Coefficients and Absolute Terms—*continued.*

Equation B_{10} (*cont.*).

Δ.	y.	z.
122*	+0·136	+0·924
123*	−0·792	+0·218
124*	−0·029	+0·790
125*	−1·215	−0·211
126*	−1·125	+0·641
127*	−0·122	+1·209
128*	+0·199	+0·830
129*	−0·935	+0·526
130*	−0·561	+0·518
131*	−0·132	+0·179

Absolute Term + 5·27.

Equation B_{11}.

Δ.	y.	z.
56	−0·407	−1·025
76*	−0·668	+0·561
77	+0·288	+0·908
78	−1·067	+0·385
79*	+0·263	+0·846
80*	−0·062	+0·375
81*	−0·412	+0·521
82	−2·665	−0·991
83	−0·081	+1·956
84*	−0·661	−0·242
85*	−0·456	+0·288
86	+0·054	+0·916
87	−1·254	+0·481
88*	−0·030	+1·061
89*	−0·851	+0·455
90*	−0·749	+0·387
91*	−0·576	+0·738
92*	−0·910	+0·654
93*	−0·121	+0·980
94*	−0·164	+0·689
95*	−0·382	+0·412
96*	−0·854	+0·368
97*	−0·520	+0·990
98*	+0·372	+1·523

Absolute Term −9·97.

Equation B_{12}.

Δ.	y.	z.
48	+1·657	+0·244
49	+0·489	−0·436
50	+0·381	−0·672
51	+0·096	−0·451
52	+0·376	−0·188
53	+0·718	−0·488
54	+0·222	−0·374
55	−0·036	−0·390
74	−0·758	0·000
75	−0·468	+0·536

Absolute Term + 0·66.

Equation Y_1.

Δ.	y.	z.
6	+0·627	−0·653
7	+1·567	+0·765
8	+0·379	−1·262

Equation Y_1 (*cont.*).

Δ.	y.	z.
9	+3·290	+0·813
10	−1·094	−3·122
11	+2·870	+0·893
12	+4·116	+0·314
13	+3·655	+1·956
14	+1·333	−4·150
15	+4·662	+0·374
16	−3·174	−7·412
17	+5·095	+2·561
18	−1·582	−6·829
19	+7·306	+4·163
20	−2·548	−9·080
21	+9·321	+4·451
22	+9·771	+3·929
23	+7·592	+3·986
24	−4·368	−7·515
25	+9·093	+5·031
26	−6·358	−9·197
27	+7·553	+4·584
28	−6·441	−8·584
29	+6·311	+5·182
30	−6·381	−7·277
31	+6·374	+5·979
32	−6·466	−6·341
33	+6·355	+5·246
34	−5·279	−4·999
35	+4·649	+4·112
36	−3·388	−2·513
37	+2·610	+2·258
38	−1·947	−1·436
39	+2·022	+1·152
40	−0·933	−0·902
41	+0·971	+0·130

Absolute Term + 3·8.

Equation Y_2.

Δ.	y.	z.
22	+0·354	−0·651
23	−0·021	−0·641
24	+1·911	+0·850
25	+0·499	−1·127
26	+1·290	−0·616
27	+0·576	−1·511
28	+1·499	−1·565
29	+0·650	−1·208
30	+3·548	+0·481
42	+0·469	+0·936
43	−4·495	−4·529
44	+2·883	+4·079
45	+3·504	+5·905
46	−7·572	−4·967
47	+3·827	+5·729
48	−0·306	+5·106
49	−5·574	−1·868
50	+1·859	+5·157
51	−3·019	−0·713
52	+1·333	+2·998
53	−4·877	+0·027
54	+0·566	+2·475
55	−1·225	+0·313

Absolute Term + 6·1.

Equation Y_3.

Δ.	y.	z.
1	− 3·124	−7·787
2	+ 6·114	+3·000
3	− 0·969	−5·619
4	+10·640	+0·277
5	− 1·454	−6·973
6	+ 1·911	−7·116
36	− 6·217	−0·153
37	− 4·552	+1·291
38	− 2·362	+5·122
39	− 5·152	+2·460
40	− 3·826	−1·583
41	− 1·513	+3·683
66	+ 0·800	+0·769
67	− 0·385	+0·267
68	− 1·097	−0·251
69	− 0·625	+0·703
70	− 2·695	−0·269
71	− 0·650	+2·428
72	− 3·124	+1·623
73	− 2·619	+3·917

Absolute Term + 22·8.

Equation Y_4.

Δ.	y.	z.
31	−2·150	+1·593
32	+3·609	+8·477
33	−7·579	+2·165
34	−3·107	+7·212
35	−5·103	+0·838
56	+7·050	+0·607
57	+5·092	+0·683
58	−2·517	−6·354
59	−0·253	−5·563
60	+3·162	−0·762
61	−0·801	−5·988
62	+5·184	+2·424
63	+3·954	−0·069
64	−0·980	−2·888
65	+1·516	+0·517
66	−0·800	−0·769
67	+0·385	−0·267
68	+1·097	+0·251
69	+0·625	−0·703
70	+2·695	+0·269
71	+0·650	−2·428
72	+3·124	−1·623
73	+2·619	−3·917

Absolute Term — 10·0.

Equation Y_5.

Δ.	y.	z.
56	−0·943	+1·446
57	+1·972	+3·213
58	−2·505	−2·063
59	−3·104	−2·984
60	+3·500	+3·515
61	−2·769	−3·526
62	+4·689	+3·726
63	+4·232	+2·901
64	−2·674	−4·085
88*	+0·050	+0·524

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* Half weight.

Table E—*continued.*

VALUES OF THE COEFFICIENTS AND ABSOLUTE TERMS—*continued.*

Equation Y_5 (*cont.*).

Δ.	y.	z.
89*	−0·428	−0·499
90*	+0·104	+0·473
91*	−0·821	−0·500
92*	+0·062	+1·018
93*	−1·012	−0·369
94*	+0·528	+1·297
95*	−1·518	−0·858
96*	−1·911	−0·895
97*	+0·772	+2·607
98*	−1·475	−0·522
99*	+0·179	+0·312
100*	−0·735	−0·493
101*	−0·064	+0·565
102*	−0·736	−0·388
103*	+0·107	+0·703
104*	+0·622	+1·023
105*	−1·442	−0·585
106*	−0·939	−0·348
107*	+1·117	+1·288
108*	+0·766	+1·423
109*	−1·344	−0·191
110*	−0·352	+1·010
111*	+0·760	+1·173
112*	+1·204	+2·630
113*	−2·722	−0·924
114	+1·188	+2·284
115	−5·998	−2·089
116*	−1·918	−1·256
117	+1·584	+4·869
118	−4·284	−1·914
119	+1·493	+2·988
120	−3·251	+0·624
121	+1·643	+3·455
122*	+2·605	+3·803
123*	−3·514	−2·332
124*	−2·683	−1·668
125*	+1·260	+2·645
126*	+1·384	+3·820
127*	−3·273	−1·578
128*	−2·864	−2·058
129*	+1·749	+4·162
130*	−4·331	−2·806
131*	+3·372	+3·914

Absolute Term − 3·0.

EQUATION Y_6.

Δ.	y.	z.
48	+0·311	+1·818
49	−1·680	−1·854
50	+2·098	+2·806
51	−2·727	−2·957
52	+2·658	+3·126
53	−3·221	−3·568
54	+4·008	+4·337
55	−4·017	−4·222
56	+4·206	−0·786
74	−1·916	−1·771
75	+0·123	+1·049
76*	−3·288	−0·125
77	+2·176	+4·085
78	−4·517	−0·775
79*	−1·089	+0·413

Equation Y_6 (*cont.*).

Δ.	y.	z.
80*	−1·927	−0·801
81*	+1·044	+3·548
82	−5·002	−0·510
83	+1·932	+7·399
84*	−4·226	−3·173
85*	−3·676	−1·841
86	+2·703	+5·171
87	−6·015	−1·657
88*	−2·941	−0·201
89*	+1·156	+4·508
90*	−4·851	−2·366
91*	+2·240	+5·220
92*	−5·214	−2·236
93*	+3·573	+5·696
94*	−3·806	−2·558
95*	+3·424	+4·759
96*	+2·631	+4·685
97*	−4·943	−2·986
98*	+5·275	+7·214

Absolute Term + 0·2.

EQUATION X_1.

Δ.	y.	z.
6	+ 0·709	+0·972
7	+ 0·066	−0·842
8	+ 1·579	+1·079
9	− 0·540	−2·834
10	+ 3·020	+1·653
11	− 1·426	−3·569
12	− 1·707	−5·541
13	− 2·173	−3·886
14	+ 7·273	+2·767
15	− 2·218	−6·593
16	+ 5·502	+0·686
17	− 2·695	−6·840
18	+ 3·432	+1·847
19	− 0·653	−5·631
20	+ 3·351	−0·514
21	+ 1·063	−6·854
22	+ 2·489	−9·593
23	− 2·017	−9·475
24	+11·391	+3·225
25	+ 2·215	−3·062
26	+ 5·683	−3·293
27	− 0·040	−3·751
28	+ 5·044	−4·495
29	− 1·253	−5·992
30	+ 3·250	+0·919
31	− 1·621	−5·401
32	− 0·721	−6·364
33	+ 3·919	−4·789
34	+ 4·383	−5·189
35	+ 2·321	−1·742
36	+ 2·175	−1·025
37	+ 1·783	−0·430
38	− 0·040	−2·726
39	+ 0·654	−0·769
40	+ 0·152	−0·220
41	− 0·611	−1·566

Absolute Term — 14·5.

EQUATION X_2.

Δ	y.	z.
22	−0·689	−0·458
23	−0·603	−0·461
24	+0·091	+0·961
25	−1·334	−0·906
26	+1·319	+2·030
27	−1·614	−1·655
28	+2·126	+2·654
29	−2·424	−2·846
30	+2·571	+3·044
42	+0·812	−0·098
43	+2·478	+0·694
44	+4·617	+1·813
45	+3·163	−2·465
46	+0·918	−3·748
47	+3·129	+0·623
48	+8·532	+1·438
49	−2·288	−5·582
50	+4·296	+1·082
51	−3·966	−5·396
52	+3·870	+2·492
53	−2·661	−5·022
54	+3·486	+2·725
55	−4·393	−4·882

Absolute Term — 2·5.

EQUATION X_3.

Δ	y.	z.
1	−6·510	−1·888
2	+4·851	+7·422
3	−7·880	−3·834
4	+1·386	+8·446
5	−6·722	−3·380
6	+6·446	+4·308
36	−4·089	−5·012
37	+7·038	+5·953
38	−5·007	−7·106
39	+8·889	+6·229
40	−4·902	−5·900
41	+6·746	+3·891
66	−0·392	+0·418
67	+0·618	+0·972
68	−1·141	−1·316
69	−1·288	−1·515
70	+1·324	+1·928
71	+2·686	+3·089
72	−2·881	3·640
73	+3·750	+4·252

Absolute Term — 23·0.

EQUATION X_4

Δ	y.	z.
31	+6·859	+8·661
32	−5·311	−2·600
33	+4·532	+8·120
34	−7·117	−3·805
35	+5·648	+6·484
56	−2·175	−6·976
57	−3·634	−6·919
58	+4·860	+1·320

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* Half weight.

Table E—*continued.*

VALUES OF THE COEFFICIENTS AND ABSOLUTE TERMS—*continued.*

EQUATION X_4 (*cont.*).

Δ	y	z
59	+5·727	+1·814
60	−2·944	−5·745
61	+5·008	+0·005
62	−0·011	−2·453
63	−1·099	−4·661
64	+8·619	+1·875
65	−0·416	−1·616
66	+0·892	−0·418
67	−0·618	−0·972
68	+1·141	+1·816
69	+1·238	+1·515
70	−1·324	−1·928
71	−2·686	−3·089
72	+2·881	+3·640
73	−3·750	−4·252

Absolute Term − 3·2

EQUATION X_5

Δ	y	z
56	+2·029	+1·554
57	+2·116	−0·102
58	+0·206	−2·151
59	+2·280	−2·872
60	+0·728	−3·262
61	+2·580	−2·744
62	+3·286	−0·651
63	+1·581	−4·209
64	+3·909	+0·388
88*	+0·436	−0·033
89*	+0·458	−0·162
90*	+0·584	+0·190
91*	+0·147	−0·747
92*	+1·168	+0·206
93*	−0·469	−1·505
94*	+1·070	+0·520
95*	−0·872	−1·326
96*	+0·194	−1·273
97*	+1·946	−0·174
98*	−1·491	−8·544
99*	−0·275	−0·182
100*	−0·268	+0·487
101*	−1·002	−0·426
102*	+0·392	+0·927
103*	−1·018	−0·549
104*	−0·612	−0·299
105*	+0·185	+1·023
106*	+0·657	+1·270
107*	−0·794	−0·709
108*	−1·040	−0·580
109*	+0·451	+1·841
110*	−2·570	−1·386
111*	−1·608	−1·245
112*	−1·218	+0·022
113*	−0·041	+2·085
114	−1·884	−0·909
115	−8·642	+1·140
116*	+1·292	+2·084
117	−1·984	+1·298
118	−1·881	+1·564
119	−2·308	−0·884
120	−0·258	+5·614
121	−2·712	+0·147
122*	−1·194	+0·696
123*	−0·880	+1·784
124*	+1·074	+8·214

EQUATION X_5 (*cont.*).

Δ	y	z
125*	−4·947	−1·999
126*	−4·682	+0·508
127*	+0·897	+5·047
128*	+1·898	+8·865
129*	−4·731	+0·080
130*	−0·571	+8·246
131*	−2·218	−1·098

Absolute Term + 2·6

EQUATION X_6

Δ	y	z
48	+2·936	+0·244
49	+1·055	−0·584
50	+1·569	−0·910
51	+0·688	−0·826
52	+1·955	+0·281
53	+2·748	−1·886
54	+1·477	−0·988
55	+0·434	−0·981
56	−2·606	−4·681
74	−1·151	+0·192
75	−1·188	−0·626
76*	+1·526	+8·454
77	−2·515	−1·522
78	+0·691	+3·258
79*	+3·042	+4·072
80*	+2·467	+3·240
81*	−3·569	−1·564
82	−8·413	−4·814
83	−2·858	+1·521
84*	+0·819	+1·893
85*	+1·343	+8·253
86	−2·726	−0·529
87	−1·082	+3·890
88*	+2·426	+5·552
89*	−5·409	−1·047
90*	−0·219	+8·481
91*	−4·810	+0·850
92*	−1·264	+4·181
93*	−2·889	+1·802
94*	+0·972	+8·828
95*	−8·234	−0·005
96*	−5·158	−0·184
97*	−0·924	+5·523
98*	+0·045	+5·896

Absolute Term − 32·9

EQUATION A_1

Δ	y	z
6	0	−1
7	+1	+1
8	−1	−1
9	+1	+1
10	−1	−1
11	+1	+1
12	+1	+1
13	+1	+1
14	−1	−1
15	+1	+1
16	−1	−1
17	+1	+1
18	−1	−1

EQUATION A_1 —(*cont.*)

Δ	y	z
19	+1	+1
20	−1	−1
21	+1	+1
22	+1	+1
23	+1	+1
24	−1	−1
25	+1	+1
26	−1	−1
27	+1	+1
28	−1	−1
29	+1	+1
30	−1	−1
31	+1	+1
32	−1	−1
33	+1	+1
34	−1	−1
35	+1	+1
36	−1	−1
37	+1	+1
38	−1	−1
39	+1	+1
40	−1	−1
41	+1	+1

Absolute Term +1·04

EQUATION A_2

Δ	y	z
22	0	−1
23	−1	−1
24	+1	+1
25	−1	−1
26	+1	+1
27	−1	−1
28	+1	+1
29	−1	−1
30	+1	+1
42	+1	+1
43	−1	−1
44	+1	+1
45	+1	+1
46	−1	−1
47	+1	+1
48	+1	+1
49	−1	−1
50	+1	+1
51	−1	−1
52	+1	+1
53	−1	−1
54	+1	+1
55	−1	−1

Absolute Term +0·48

EQUATION A_3

Δ	y	z
1	+1	+1
2	−1	−1
3	+1	+1
4	−1	−1
5	+1	+1
6	−1	0
36	+1	+1
37	−1	−1

* Half Weight.

Table II—*concluded.*

VALUES OF THE COEFFICIENTS AND ABSOLUTE TERMS—*concluded.*

Equation A_3 (*cont.*).

Δ	y.	z.
38	+1	+1
39	−1	−1
40	+1	+1
41	−1	−1
66	0	−1
67	−1	−1
68	+1	+1
69	+1	+1
70	−1	−1
71	−1	−1
72	+1	+1
73	−1	−1

Absolute Term +0·72

EQUATION A_4

Δ	y.	z.
31	−1	−1
32	+1	+1
33	−1	−1
34	+1	+1
35	−1	−1
56	+1	+4
57	+1	+1
58	−1	−1
59	−1	−1
60	+1	+1
61	−1	−1
62	+1	+1
63	+1	+1
64	−1	−1
65	+1	+1
66	−1	0
67	+1	+1
68	−1	−1
69	−1	−1
70	+1	+1
71	+1	+1
72	−1	−1
73	+1	+1

Absolute Term +0·55

EQUATION A_5

Δ	y.	z.
56	0	−1
57	−1	−1
58	+1	+1
59	+1	+1
60	−1	−1
61	+1	+1
62	−1	−1
63	−1	−1
64	+1	+1
88*	0	−1
89*	+1	+1
90*	−1	−1
91*	+1	+1
92*	−1	−1
93*	+1	+1
94*	−1	−1
95*	+1	+1
96*	+1	+1
97*	−1	−1
98*	+1	+1
99*	−1	−1
100*	+1	+1
101*	−1	−1
102*	+1	+1
103*	−1	−1
104*	−1	−1
105*	+1	+1
106*	+1	+1
107*	−1	−1
108*	−1	−1
109*	+1	+1
110*	−1	−1
111*	−1	−1
112*	−1	−1
113*	+1	+1
114	−1	−1
115	+1	+1
116*	+1	+1
117	−1	−1
118	+1	+1
119	−1	−1
120	+1	+1
121	−1	−1
122*	−1	−1
123*	+1	+1
124*	+1	+1
125*	−1	−1
126*	−1	−1

Equation A_5 (*cont.*).

Δ	y.	z.
127*	+1	+1
128*	+1	+1
129*	−1	−1
130*	+1	+1
131*	−1	−1

Absolute Term +8·50

EQUATION A_6

Δ	y.	z.
48	0	−1
49	+1	+1
50	−1	−1
51	+1	+1
52	−1	−1
53	+1	+1
54	−1	−1
55	+1	+1
56	−1	0
74	+1	+1
75	−1	−1
76*	+1	+1
77	−1	−1
78	+1	+1
79*	+1	+1
80*	+1	+1
81*	−1	−1
82	−1	−1
83	−1	−1
84*	+1	+1
85*	+1	+1
86	−1	−1
87	+1	+1
88*	+1	+1
89*	−1	−1
90*	+1	+1
91*	−1	−1
92*	+1	+1
93*	−1	−1
94*	+1	+1
95*	−1	−1
96*	−1	−1
97*	+1	+1
98*	−1	−1

Absolute Term −2·95

NORMALS IN SOLUTION OF CIRCUITS.

$$+ 11{\cdot}7416B_1 - 4{\cdot}5239B_4 + 13{\cdot}0811Y_1 + 29{\cdot}0843Y_3 + 20{\cdot}6890X_1 - 11{\cdot}2868X_3 + 0{\cdot}0830A_1 - 1{\cdot}1840A_3 = 0$$

$$+13{\cdot}3982B_2 - 8{\cdot}0692B_5 + 14{\cdot}6802Y_1 + 13{\cdot}9668Y_2 + 95{\cdot}3062X_1 + 3{\cdot}3785X_2 - 3{\cdot}5960A_1 + 4{\cdot}3820A_2 - 1{\cdot}00 = 0$$

$$+ 4{\cdot}8983B_3 + 5{\cdot}0589Y_1 - 30{\cdot}4273Y_4 + 27{\cdot}8783X_1 - 6{\cdot}9843X_4 + 0{\cdot}7740A_1 - 0{\cdot}7740A_4 + 1{\cdot}42 = 0$$

$$- 4{\cdot}5239B_1 + 11{\cdot}2215B_4 + 1{\cdot}9990Y_1 - 62{\cdot}2697Y_3 + 11{\cdot}3540X_1 + 35{\cdot}5911X_3 - 0{\cdot}0320A_1 - 0{\cdot}9490A_3 - 1{\cdot}85 = 0$$

* Half Weight.

NORMALS IN SOLUTION OF CIRCUITS—*continued.*

$$-8\cdot0692B_2+9\cdot4901B_5-2\cdot3218Y_1-16\cdot6251Y_2-61\cdot4506X_1-0\cdot8200X_2+2\cdot3620A_1-4\cdot0130A_2+2\cdot85=0$$

$$+7\cdot2409B_6+4\cdot7562B_{12}-22\cdot5503Y_2+0\cdot5880Y_6+26\cdot8741X_2+10\cdot8646X_6+0\cdot1150A_2+0\cdot1530A_6-3\cdot32=0$$

$$+9\cdot1014B_7-0\cdot3248B_9-18\cdot2627Y_3+18\cdot2627Y_4-4\cdot4970X_3+4\cdot4970X_4+2\cdot2480A_3-0\cdot2880A_4-1\cdot47=0$$

$$+8\cdot6545B_8-0\cdot3860B_{10}+0\cdot3860B_{11}+29\cdot6091Y_4+1\cdot7557Y_5+3\cdot5603Y_6+23\cdot2140X_4+25\cdot2419X_5+1\cdot9977X_6+0\cdot3830A_4+0\cdot3480A_5-0\cdot7810A_6=0$$

$$-0\cdot3248B_7+1\cdot1475B_9+0\cdot0521Y_3+0\cdot3069Y_4-0\cdot4182X_3+1\cdot2587X_4+0\cdot4940A_3-0\cdot7280A_4=0$$

$$-0\cdot3860B_8+83\cdot6875B_{10}-19\cdot5356B_{11}+3\cdot4916Y_4+55\cdot6562Y_5-57\cdot7692Y_6-8\cdot0356X_4+137\cdot1890X_5-65.8987X_6+1\cdot4320A_4-6\cdot4230A_5+6\cdot6750A_6+5\cdot27=0$$

$$+0\cdot3860B_8-19\cdot5356B_{10}+46\cdot1780B_{11}-3\cdot4916Y_4+7\cdot6510Y_5+116\cdot5446Y_6+8\cdot0356X_4-26\cdot1608X_5+135\cdot7828X_6-1\cdot4320A_4+2\cdot3770A_5-2\cdot5200A_6-9\cdot97=0$$

$$+4\cdot7562B_6+6\cdot3975B_{12}-8\cdot3531Y_2+3\cdot7844Y_6+22\cdot1339X_2+12.8277X_6+2\cdot1440A_2-1\cdot3130A_6+0\cdot66=0$$

$$+13\cdot0311B_1+14\cdot6802B_2+5\cdot0539B_3+1\cdot9990B_4-2\cdot3218B_5+1733\cdot0106Y_1-47\cdot2764Y_2+15\cdot5762Y_3-158\cdot0038Y_4-491\cdot8398X_1-191\cdot1656X_2+121\cdot5421X_3+327\cdot2175X_4+292\cdot5710A_1-109\cdot3770A_2-20\cdot8890A_3-55\cdot8000A_4+3\cdot80=0$$

$$+18\cdot9668B_2-16\cdot6251B_5-22\cdot5503B_6-8\cdot3531B_{12}-47\cdot2764Y_1+417\cdot2737Y_2+95\cdot8466Y_6+121\cdot1402X_1+140\cdot7110X_2-20\cdot1332X_6-10\cdot4730A_1+95\cdot8460A_2-36\cdot4300A_6+6\cdot10=0$$

$$+29\cdot0848B_1-62\cdot2697B_4-18\cdot2627B_7+0\cdot0521B_9+15\cdot5762Y_1+638\cdot8859Y_3-51\cdot8508Y_4-61\cdot4046X_1+179\cdot2478X_3-12\cdot9464X_4+20\cdot3280A_1-64\cdot6140A_3+1\cdot9650A_4+22\cdot8=0$$

$$-30\cdot4273B_3+18\cdot2627B_7+29\cdot6091B_8+0\cdot3069B_9+3\cdot4916B_{10}-3\cdot4916B_{11}-158\cdot0038Y_1-51\cdot8508Y_3+555\cdot8544Y_4+138\cdot7378Y_5+29\cdot1752Y_6-166\cdot0836X_1-12\cdot9464X_3-174\cdot6502X_4+87\cdot9297X_5-22\cdot2055X_6-26\cdot4270A_1+3\cdot5340A_3+79\cdot1140A_4-45\cdot5690A_5-7\cdot0500A_6-10\cdot00=0$$

$$+1\cdot7557B_8+55\cdot6562B_{10}+7\cdot6510B_{11}+138\cdot7378Y_4+774\cdot7827Y_5-133\cdot8053Y_6-160\cdot9996X_4-155\cdot8077X_5+89\cdot2071X_6+51\cdot8610A_4-293\cdot3270A_5+37\cdot4190A_6-3\cdot00=0$$

$$+0\cdot5880B_6+3\cdot5603B_8-57\cdot7692B_{10}+116\cdot5446B_{11}+3\cdot7844B_{12}+95\cdot8466Y_2+29\cdot1752Y_4-133\cdot8053Y_5+1255\cdot5649Y_6+166\cdot7750X_2-3\cdot6650X_4-164\cdot8860X_5-155\cdot8434X_6+45\cdot3980A_2+3\cdot4200A_4+159\cdot8700A_5-298\cdot6860A_6+0\cdot20=0$$

$$+20\cdot6890B_1+95\cdot3062B_2+27\cdot8783B_3+11\cdot3540B_4-61\cdot4506B_5-491\cdot8398Y_1+121\cdot1402Y_2-61\cdot4046Y_3-166\cdot0836Y_4+1865\cdot5717X_1+74\cdot9338X_2+25\cdot9227X_3-68\cdot2941X_4-160\cdot8500A_1+69\cdot6420A_2-1\cdot4540A_3-0\cdot5780A_4-14\cdot50=0$$

$$+3\cdot3785B_2-0\cdot8200B_5+26\cdot8741B_6+22\cdot1339B_{12}-191\cdot1656Y_1+140\cdot7110Y_2+166\cdot7750Y_6+74\cdot9338X_1+422\cdot1578X_2+47\cdot0510X_6-27\cdot7860A_1+100\cdot4100A_2-53\cdot5290A_6-2\cdot50=0$$

$$-11\cdot2868B_1+35\cdot5911B_4-4\cdot4970B_7-0\cdot4182B_9+121\cdot5421Y_1+179\cdot2478Y_3-12\cdot9464Y_4+25\cdot9227X_1+914\cdot2405X_3-84\cdot1691X_4+66\cdot4540A_1-160\cdot1400A_3+30\cdot6920A_4-23\cdot00=0$$

$$-6\cdot9343B_3+4\cdot4970B_7+23\cdot2140B_8+1\cdot2587B_9-8\cdot0356B_{10}+8\cdot0356B_{11}+327\cdot2175Y_1-12\cdot9464Y_3-174\cdot6502Y_4-160\cdot9996Y_5-3\cdot6650Y_6-68\cdot2941X_1-84\cdot1691X_3+754\cdot5189X_4+49\cdot2591X_5+49\cdot7215X_6+59\cdot1320A_1+30\cdot7180A_3-151\cdot7010A_4+57\cdot6700A_5+2\cdot1750A_6-3\cdot20=0$$

$$+25\cdot2419B_8+137\cdot1890B_{10}-26\cdot1698B_{11}+87\cdot9297Y_4-155\cdot8077Y_5-164\cdot8860Y_6+49\cdot2591X_4+610\cdot6865X_5-60\cdot0773X_6+0\cdot9740A_4+114\cdot9190A_5+29\cdot9770A_6+2\cdot60=0$$

$$+10\cdot8646B_6-1\cdot9977B_8-65\cdot8987B_{10}+135\cdot7828B_{11}+12\cdot8227B_{12}-20\cdot1332Y_2-22\cdot2055Y_4+89\cdot2071Y_5-155\cdot8434Y_6+47\cdot0510X_2+49\cdot7215X_4-60\cdot0773X_5+884\cdot6541X_6+5\cdot4210A_2-8\cdot9210A_4-64\cdot1110A_5+165\cdot3460A_6-32\cdot90=0$$

NORMALS IN SOLUTION OF CIRCUITS—*continued.*

$$\begin{aligned}&+0\cdot0830B_1-3\cdot5960B_2+0\cdot7740B_3-0\cdot0320B_4+2\cdot3620B_5+292\cdot5710Y_1\\&-10\cdot4780Y_2+20\cdot3280Y_3-26\cdot4270Y_4-160\cdot8500X_1-27\cdot7860X_2\\&+66\cdot4540X_3+59\cdot1320X_4+71\cdot0000A_1-17\cdot0000A_2-12\cdot0000A_3-10\cdot0000A_4+1\cdot04=0\end{aligned}$$

$$\begin{aligned}&+4\cdot3820B_2-4\cdot0130B_5+0\cdot1150B_6+2\cdot1440B_{12}-109\cdot3770Y_1+95\cdot8460Y_2\\&+45\cdot3980Y_6+69\cdot6420X_1+100\cdot4100X_2+5\cdot4210X_6-17\cdot0000A_1+45\cdot0000A_2\\&-15\cdot0000A_6+0\cdot43=0\end{aligned}$$

$$\begin{aligned}&-1\cdot1840B_1-0\cdot9490B_4+2\cdot2480B_7+0\cdot4940B_9-20\cdot8890Y_1-64\cdot6140Y_3\\&+3\cdot5840Y_4-1\cdot4540X_1-160\cdot1400X_3+30\cdot7180X_4-12\cdot0000A_1+38\cdot0000A_3\\&-14\cdot0000A_4+0\cdot72=0\end{aligned}$$

$$\begin{aligned}&-0\cdot7740B_3-0\cdot2880B_7+0\cdot3880B_8-0\cdot7230B_9+1\cdot4320B_{10}-1\cdot4320B_{11}\\&-55\cdot8000Y_1+1\cdot9650Y_3+79\cdot1140Y_4+51\cdot8610Y_5+3\cdot4200Y_6-0\cdot5780X_1\\&+30\cdot6920X_3-151\cdot7010X_4+0\cdot9740X_5+8\cdot9210X_6-10\cdot0000A_1-14\cdot0000A_3\\&+45\cdot0000A_4-17\cdot000A_5-1\cdot0000A_6+0\cdot55=0\end{aligned}$$

$$\begin{aligned}&+0\cdot3480B_8-6\cdot4280B_{10}+2\cdot3770B_{11}-45\cdot5690Y_4-293\cdot3270Y_5\\&+159\cdot8700Y_6+57\cdot6700X_4+114\cdot9190X_5-64\cdot1110X_6-17\cdot0000A_4\\&+177\cdot0000A_5-42\cdot0000A_6+8\cdot50=0\end{aligned}$$

$$\begin{aligned}&+0\cdot1530B_6-0\cdot7810B_8+6\cdot6750B_{10}-2\cdot5200B_{11}-1\cdot3180B_{12}-36\cdot4300Y_2\\&-7\cdot0500Y_4+87\cdot4190Y_5-298\cdot6860Y_6-53\cdot5290X_2+2\cdot1750X_4+29\cdot9770X_5\\&+165\cdot3460X_6-15\cdot0000A_2-1\cdot0000A_4-42\cdot0000A_5+100\cdot0000A_6-2\cdot95=0\end{aligned}$$

VALUES OF THE FACTORS.

Factor.	Value.	Factor.	Value.	Factor.	Value.
B_1	+0·31089	B_{11}	+0·36982	X_3	+0·34761
B_2	−0·01258	B_{12}	−1·02095	X_4	+0·06514
B_3	−0·09178	Y_1	+0·00234	X_5	+0·03535
B_4	−2·38039	Y_2	+0·05703	X_6	+0·04261
B_5	−0·37832	Y_3	−0·29352	A_1	−0·22863
B_6	+1·61305	Y_4	−0·02702	A_2	+0·01667
B_7	−0·45900	Y_5	−0·05517	A_3	+0·90854
B_8	−0·19919	Y_6	−0·10911	A_4	+0·27726
B_9	−0·27092	X_1	−0·03450	A_5	−0·16446
B_{10}	−0·01376	X_2	−0·09488	A_6	−0·46101

Table F.

SOLUTION OF CIRCUIT EQUATIONS.

Resulting Corrections.

Δ	x	y	z	Δ	x	y	z
	″	″	″		″	″	″
1	−1·89	+0·48	+0·91	67	+0·36	−0·38	+0·02
2	+0·49	−0·45	−0·04	68	−0·64	+0·31	+0·33
3	−0·75	+0·28	+0·52	69	−0·68	+0·32	+0·36
4	+0·33	−0·59	+0·26	70	+0·05	−0·08	+0·03
5	+0·02	−0·09	+0·07	71	−0·32	+0·24	+0·08
6	−0·80	+0·32	+0·48	72	+0·24	+0·29	−0·53
7	+0·16	+0·07	−0·23	73	−0·87	+0·86	+0·01
8	−0·35	+0·36	−0·01	74	−0·21	+0·47	−0·26
9	+0·24	+0·04	−0·28	75	−0·65	+0·88	−0·23
10	−0·19	+0·20	−0·01	76	+0·76	−0·57	−0·19
11	+0·39	−0·08	−0·31	77	−0·50	+0·21	+0·29
12	+0·35	−0·03	−0·32	78	+0·43	−0·33	−0·10
13	+0·26	−0·07	−0·19	79	+0·27	−0·23	−0·04
14	−0·38	+0·35	+0·03	80	+0·53	−0·34	−0·19
15	+0·31	−0·03	−0·28	81	−0·49	+0·09	+0·40
16	−0·23	+0·03	+0·20	82	+0·38	−0·33	−0·05
17	+0·12	−0·13	+0·01	83	−0·54	+0·10	+0·44
18	−0·07	−0·08	+0·15	84	+0·67	−0·42	−0·25
19	+0·22	−0·20	−0·02	85	+0·38	−0·35	−0·03
20	−0·15	−0·08	+0·23	86	−0·28	+0·07	+0·21
21	+0·23	−0·25	+0·02	87	+0·26	−0·32	+0·06
22	−0·33	+0·16	+0·17	88	−0·53	−0·09	+0·62
23	+0·26	−0·03	−0·23	89	+0·78	−0·69	−0·09
24	−0·44	+0·35	+0·09	90	−0·38	−0·10	+0·48
25	+0·10	+0·11	−0·21	91	+0·55	−0·60	+0·05
26	+0·02	+0·15	−0·17	92	−0·48	−0·18	+0·66
27	+0·13	+0·08	−0·21	93	+0·22	−0·41	+0·19
28	+0·16	+0·11	−0·27	94	−0·90	+0·22	+0·68
29	0·00	+0·09	−0·09	95	+0·71	−0·58	−0·13
30	−0·21	+0·27	−0·06	96	+1·00	−0·85	−0·15
31	−0·36	+0·08	+0·28	97	−1·06	+0·07	+0·99
32	−0·48	+0·08	+0·40	98	−0·25	−0·21	+0·46
33	−0·01	−0·20	+0·21	99	−0·56	+0·29	+0·27
34	−0·20	−0·12	+0·32	100	+0·49	−0·24	−0·25
35	+0·14	−0·13	−0·01	101	−0·52	+0·29	+0·28
36	+1·38	−1·13	−0·25	102	+0·46	−0·22	−0·24
37	−1·02	+0·38	+0·64	103	−0·47	+0·26	+0·21
38	+0·13	−0·31	+0·18	104	−0·38	+0·21	+0·17
39	−1·16	+0·73	+0·43	105	+0·34	−0·14	−0·20
40	+0·10	−0·03	−0·07	106	+0·39	−0·17	−0·22
41	−0·38	+0·41	−0·03	107	−0·27	+0·14	+0·13
42	−0·05	−0·28	+0·33	108	−0·28	+0·17	+0·11
43	+1·10	−0·71	−0·39	109	+0·35	−0·14	−0·21
44	−0·97	+0·87	+0·10	110	−0·34	+0·22	+0·12
45	+0·60	+0·47	−1·07	111	−0·25	+0·14	+0·11
46	−0·47	+0·64	−0·17	112	−0·12	+0·11	+0·01
47	+0·72	−0·03	−0·69	113	+0·10	−0·01	−0·09
48	+0·57	−0·13	−0·44	114	−0·04	+0·04	0·00
49	+0·20	−0·06	−0·14	115	−0·07	+0·08	−0·01
50	−0·16	+0·24	−0·08	116	+0·07	−0·02	−0·05
51	−0·12	+0·11	+0·01	117	+0·03	+0·02	−0·05
52	−0·17	+0·20	−0·03	118	−0·02	+0·03	−0·01
53	−0·43	+0·39	+0·04	119	+0·01	+0·01	−0·02
54	+0·45	−0·07	−0·38	120	+0·01	+0·02	−0·03
55	−0·51	+0·31	+0·20	121	+0·05	−0·02	−0·03
56	+0·85	−0·34	−0·51	122	+0·11	−0·05	−0·06
57	+0·12	−0·03	−0·09	123	−0·06	+0·02	+0·04
58	−0·04	+0·04	0·00	124	−0·10	+0·04	+0·06
59	−0·07	+0·04	+0·03	125	+0·23	−0·13	−0·10
60	+0·07	−0·04	−0·03	126	+0·20	−0·13	−0·07
61	−0·03	+0·01	+0·02	127	−0·27	+0·10	+0·17
62	+0·08	−0·06	−0·02	128	−0·27	+0·12	+0·15
63	+0·04	−0·05	+0·01	129	+0·31	−0·17	−0·14
64	+0·01	−0·03	+0·02	130	−0·33	+0·13	+0·20
65	−0·42	+0·09	+0·33	131	+0·38	−0·20	−0·18
66	+0·70	−0·17	−0·53				

Table G.

Values of P and Q in Supplementary Adjustment of Chains a, b, and c.

No. in Traverse.	P.	Q.	No. in Traverse.	P.	Q.	No. in Traverse.	P.	Q.
Chain a.			Chain b.			Chain c.		
98	+1·6223	+2·4732	66	+1·4648	−2·0135	112	−1·7978	−0·1362
99	+1·2758	+2·1980	104	+1·2156	−1·4840	113	−1·5604	+0·0901
100	+1·0993	+1·3314	105	+0·7214	−1·5499	114	−1·1628	+0·0638
101	+0·8295	+0·8899	106	+0·4970	−1·2261	115	−0·9996	+0·0346
102	+0·8204	+0·2458	107	+0·4275	−0·8764	116	−0·9038	−0·0966
103	0·0000	0·0000	108	+0·1592	−0·5927	117	−0·7743	−0·0084
			80	−0·1880	−0·2684	118	−0·5056	+0·0831
			81	0·0000	0·0000	81	0·0000	0·0000

Table H.

Supplementary Adjustment of Chains a, b, and c.

Values of the Coefficients and Absolute Terms.

Equation Ba.

Δ	y.	z.
56	+0·78	−0·62
57	+0·82	−0·60
58	+0·27	−0·72
59	+0·76	−0·75
60	+0·20	−0·94
61	+0·70	−1·04
62	+1·13	+0·06
63	+0·65	−0·91
64	+0·69	−0·28

Absolute Term 0·00

Equation Bb.

Δ	y.	z.
56	+0·41	+1·03
88*	+0·92	+0·89
89*	+0·85	−0·46
90*	+0·75	−0·39
91*	+0·58	−0·74
92*	+0·91	−0·65
93*	+0·12	−0·98
94*	+0·10	−0·64
95*	+0·38	−0·41
96*	+0·85	−0·37
97*	+0·52	−0·99
98*	−0·37	−1·52

Absolute Term +0·12

Equation Bc.

Δ	y.	z.
76*	+0·67	−0·56
77	−0·24	−0·90
78	+1·07	−0·89
79*	−0·26	−0·85
80*	+0·06	−0·38
81*	+0·41	−0·52
82	+2·66	+0·99
83	+0·08	−1·96
84*	+0·66	+0·24
85*	+0·46	−0·29
86	−0·05	−0·92
87	+1·25	−0·48
88*	−0·89	−1·95

Absolute Term − 0·12

Equation Ya.

Δ	y.	z.
58	−0·27	+0·62
59	−0·82	+1·59
60	−1·37	+0·15
61	−0·57	+2·51
62	−3·75	−1·40
63	−2·70	+0·73
64	−0·65	+2·01

Absolute Term − 0·50

Equation Yb.

Δ	y	z.
56	+2·29	+2·06
88*	+0·20	−0·10
89*	+0·47	+0·19
90*	+0·29	−0·39
91*	+0·79	+0·11
92*	+0·37	−1·00
93*	+0·86	−0·08
94*	−0·30	−1·28
95*	+1·43	+0·56
96*	+1·95	+0·61
97*	−0·45	−2·69
98*	+1·19	−0·07

Absolute Term +0·70

Equation Yc.

Δ	y	z.
76*	−1·62	−1·37
77	+1·54	+1·48
78	−1·50	−1·21
79*	−1·28	−1·12
80*	−1·30	−1·21
81*	+0·86	+0·96
82	+0·65	+0·81
83	+0·90	+1·09
84*	−0·67	−0·55
85*	−0·65	−0·41
86	+0·50	+0·43
87	−0·58	−0·06

Absolute Term +0·70

* Half weight.

Table H—*concluded.*

SUPPLEMENTARY ADJUSTMENT OF CHAINS *a*, *b*, AND *c*—*continued.*

EQUATION XA.

Δ	y.	z.
58	−0·89	−0·91
59	−1·75	−0·78
60	+1·11	+2·36
61	−2·25	−1·09
62	+0·76	+2·18
63	+1·37	+3·36
64	−3·60	−2·41

Absolute Term 0·00

EQUATION XB.

Δ	y.	z.
56	+1·42	−1·50
88*	−0·26	−0·47
89*	−0·03	+0·34
90*	−0·71	−0·53
91*	+0·23	+0·88
92*	−1·27	−0·60
93*	+0·76	+1·59
94*	−1·31	−0·91
95*	+0·71	+1·52
96*	+0·24	+1·47
97*	−2·12	−0·28
98*	+1·69	+3·53

Absolute Term − 0·50

EQUATION XC.

Δ	y.	z.
76*	−0·79	+1·04
77	+0·46	+1·50
78	−1·17	+0·70
79*	+0·54	+1·29
80*	+0·12	+0·69
81*	−0·47	+0·37
82	−2·51	−0·99
83	−0·17	+1·67
84*	−0·06	+0·15
85*	+0·04	+0·41
86	+0·11	+0·55
87	+0·03	+0·36

Absolute Term +0·50

EQUATION AA.

Δ	y.	z.
56	−1	−1
57	−1	−1
58	+1	+1
59	+1	+1
60	−1	−1
61	+1	+1
62	−1	−1
63	−1	−1
64	+1	+1

Absolute Term 0·00

EQUATION AB.

Δ	y.	z.
56	+1	0
88*	0	−1
89*	+1	+1
90*	−1	−1
91*	+1	+1
92*	−1	−1
93*	+1	+1
94*	−1	−1
95*	+1	+1
96*	+1	+1
97*	−1	−1
98*	+1	+1

Absolute Term 0·00

EQUATION AC.

Δ	y.	z.
76*	+1	+1
77	−1	−1
78	+1	+1
79*	+1	+1
80*	+1	+1
81*	−1	−1
82	−1	−1
83	−1	−1
84*	+1	+1
85*	+1	+1
86	−1	−1
87	+1	+1
88*	+1	0

Absolute Term 0·00

Normal Equations.

$$+8{\cdot}7B_a - 0{\cdot}3B_b - 13{\cdot}1Y_a + 0{\cdot}4Y_b - 5{\cdot}8X_a + 2{\cdot}0X_b - 0{\cdot}4A_a + 0{\cdot}7A_b = 0$$

$$-0{\cdot}3B_a + 24{\cdot}6B_b - 5{\cdot}1B_c + 16{\cdot}9Y_b - 23{\cdot}1X_b - 1{\cdot}4A_a - 4{\cdot}9A_b + 1{\cdot}8A_c + 0{\cdot}12 = 0$$

$$-5{\cdot}1B_b + 31{\cdot}8B_c - 2{\cdot}6Y_c + 2{\cdot}3X_b - 20{\cdot}8X_c + 3{\cdot}9A_b - 0{\cdot}3A_c - 0{\cdot}12 = 0$$

$$-13{\cdot}1B_a + 39{\cdot}9Y_a - 13{\cdot}2X_a + 13{\cdot}3A_a - 0{\cdot}50 = 0$$

$$+0{\cdot}4B_a + 16{\cdot}9B_b + 49{\cdot}8Y_b + 18{\cdot}7X_b - 4{\cdot}4A_a + 29{\cdot}4A_b + 0{\cdot}4A_c + 0{\cdot}70 = 0$$

$$-2{\cdot}6B_c + 38{\cdot}9Y_c - 3{\cdot}7X_c - 34{\cdot}6A_c + 0{\cdot}70 = 0$$

$$-5{\cdot}8B_a - 13{\cdot}2Y_a + 55{\cdot}4X_a - 24{\cdot}8A_a = 0$$

$$+2{\cdot}0B_a - 23{\cdot}1B_b + 2{\cdot}3B_c + 18{\cdot}7Y_b + 78{\cdot}4X_b + 0{\cdot}1A_a + 43{\cdot}7A_b - 0{\cdot}5A_c - 0{\cdot}50 = 0$$

$$-20{\cdot}8B_c - 3{\cdot}7Y_c + 24{\cdot}3X_c + 6{\cdot}4A_c + 0{\cdot}50 = 0$$

$$-0{\cdot}4B_a - 1{\cdot}4B_b + 13{\cdot}3Y_a - 4{\cdot}4Y_b - 24{\cdot}8X_a + 0{\cdot}1X_b + 18{\cdot}0A_a - 1{\cdot}0A_b = 0$$

$$+0{\cdot}7B_a - 4{\cdot}9B_b + 3{\cdot}9B_c + 29{\cdot}4Y_b + 43{\cdot}7X_b - 1{\cdot}0A_a + 43{\cdot}0A_b = 0$$

$$+1{\cdot}8B_b - 0{\cdot}3B_c + 0{\cdot}4Y_b - 34{\cdot}6Y_c - 0{\cdot}5X_b + 6{\cdot}4X_c + 38{\cdot}0A_c = 0$$

VALUES OF FACTORS.

Factor.	Value.	Factor.	Value.	Factor.	Value.	Factor.	Value.
B_a	+ 0·0624	Y_a	+ 0·0499	X_a	− 0·0078	A_a	− 0·0582
B_b	+ 0·1028	Y_b	− 0·0823	X_b	+ 0·0470	A_b	+ 0·0185
B_c	− 0·0054	Y_c	− 0·1058	X_c	− 0·0150	A_c	− 0·0969

Table J.

SUPPLEMENTARY ADJUSTMENT OF CHAINS *a*, *b* AND *c*.

Resulting Corrections.

Δ	*x*.	*y*.	*z*.	Δ	*x*.	*y*.	*z*.
	"	"	"		"	"	"
56	+0·08	+0·04	−0·12	83	+0·02	+0·01	−0·03
57	−0·10	+0·08	+0·02	84	+0·14	−0·06	−0·08
58	+0·11	−0·05	−0·06	85	+0·18	−0·06	−0·12
59	+0·03	−0·01	−0·02	86	−0·09	+0·04	+0·05
60	+0·02	−0·01	−0·01	87	+0·14	−0·05	−0·09
61	+0·01	−0·02	+0·01	88	−0·09	−0·05	+0·14
62	+0·09	−0·06	−0·03	89	−0·07	+0·13	−0·06
63	+0·04	−0·05	+0·01	90	+0·10	0·00	−0·10
64	−0·02	−0·02	+0·04	91	0·00	+0·05	−0·05
76	−0·28	+0·16	+0·07	92	+0·09	−0·03	−0·06
77	+0·15	−0·07	−0·08	93	+0·01	−0·01	0·00
78	−0·09	+0·07	+0·02	94	+0·12	−0·08	−0·04
79	−0·06	+0·05	+0·01	95	+0·05	−0·05	0·00
80	−0·18	+0·08	+0·05	96	+0·09	−0·09	0·00
81	0·00	+0·02	−0·02	97	−0·12	−0·06	+0·18
82	−0·08	+0·06	+0·02	98	+0·01	−0·08	+0·07

Table K.

ARBITRARY CORRECTIONS FOR CIRCUIT CLOSURE.

Δ	*x*.	*y*.	*z*.	Δ	*x*.	*y*.	*z*.
	"	"	"		"	"	"
31	−0·10	+0·06	+0·04	91	+0·38	−0·25	−0·13
32	+0·12	−0·07	−0·05	99	+0·11	−0·01	−0·10
33	−0·03	+0·05	−0·02	100	+0·06	+0·06	−0·12
34	−0·07	+0·01	+0·06	101	−0·08	+0·11	−0·08
35	+0·19	−0·08	−0·11	102	+0·13	−0·03	−0·10
44	+0·17	−0·07	−0·10	103	+0·01	+0·03	−0·04
45	+0·23	−0·09	−0·14	104	+0·11	−0·03	−0·08
46	+0·21	−0·05	−0·16	105	+0·01	+0·01	−0·02
47	−0·17	+0·06	+0·11	106	+0·08	−0·01	−0·02
59	−0·08	+0·12	−0·09	107	+0·08	−0·04	−0·04
60	+0·21	−0·06	−0·15	108	+0·07	−0·04	−0·08
61	+0·11	−0·01	−0·10	109	+0·05	−0·04	−0·01
62	+0·12	−0·11	−0·01	110	+0·17	−0·14	−0·08
63	−0·01	−0·07	+0·08	111	+0·06	−0·05	−0·01
64	+0·20	−0·19	−0·01	112	−0·10	−0·01	+0·11
89	0·00	+0·15	−0·15	113	+0·16	−0·20	+0·04
90	+0·34	−0·24	−0·10				

Table L.

FINAL CO-ORDINATES OF STATIONS IN CIRCUITS.

Origin ϕ_0 25°, L_0 — 29°.

Station.	Co-ordinates.	
	Y.	X.
	Eng. feet.	Eng. feet.
Breakfast Vlei	+627139·0	+2948376·0
Hogsback	+608353·5	+2767098·5
Bekruip Kop	+465795·0	+2910423·2
Gonubie	+392866·8	+2772392·5
Windvogel Berg	+582411·6	+2658539·8
Mbulu	+400707·8	+2600932·7
Lubisi	+468017·2	+2466617·6
Owecweni	+302167·9	+2500341·8
Xuka	+313707·2	+2291296·6
Bazeia	+191802·1	+2382011·1
View Hill	+165943·4	+2228866·7
Ncolora	+ 55911·3	+2314932·0
Nquashu	+ 14450·2	+2289638·7
Ladykok	+ 69850·3	+2097439·1
Insizwa	— 64737·3	+2106927·9
Jumbla	+ 37899·8	+1999865·6
Mount Currie	—182051·7	+1989017·7
Zwaartberg	—131108·2	+1862156·8
Malowe	—274923·8	+1980249·0
Mabehlan	—292590·7	+1841583·2
Marwaqa	—236779·1	+1747070·2
Byrnetown	—377066·0	+1742428·8
Inhluzan	—308137·4	+1652400·7
Zwartkop I.	—398496·2	+1671566·3
Spioenkop	—254192·8	+1617785·5
Arrochar	—351857·0	+1584355·3
Table Mountain	—205933·9	+1497400·7
Umkolumbu	—366887·4	+1418986·1
Onderbrook	—250629·6	+1327842·0
Jobskop	—389010·5	+1302938·2
Biggarsberg	—329535·7	+1169087·2
Noma Hill	—457016·5	+1174801·5
Salt Lake	—343382·4	+1061160·9
Drakensberg	—224342·1	+1083828·6
Inkwelo	—269188·5	+ 916542·8
Gemsbokberg	—138940·8	+ 893486·5
Hermitage	—111875·5	+1000122·8
Kaalkop II.	— 17369·2	+ 939571·9
Vaalbank Kop	— 8365·0	+1067799·0
Vierfontein	+134222·2	+ 978836·4
Langberg II.	+160833·9	+1176069·2
Elandskop II.	+284698·0	+ 964388·3
Kaffir Kop	+328680·9	+1181116·5
Liebenberg Stroom	+404157·0	+ 955791·3
Rietfontein	+450357·7	+1065710·0
Mijnhardt's Rust	+497886·4	+1129807·0
Zwartkrans	+316793·9	+1277418·2
Rhebokberg	+499246·0	+1404764·7
Machache	+351775·9	+1585935·3
Mabula	+552481·8	+1581172·3
Thaba Putsua	+342462·5	+1721079·8
Aasvogel Berg	+614535·3	+1930349·5
Nthodimonato	+393492·0	+1998726·0
Helvelyn	+542104·6	+2077478·1
Bendearg	+319162·6	+2222944·7
Waschbank Peak	+483659·7	+2278108·8
Nthabankulu	—432036·1	+ 907622·8
Langberg I.	—384232·4	+ 798775·5
Hlamimpesi Berg	—470569·4	+ 805035·9

Table L—*continued.*

FINAL CO-ORDINATES OF STATIONS IN CIRCUITS—*continued.*

Station.	Co-ordinates.	
	Y	X
Elandsberg III.	−333548·7	+ 727736·7
Spitzkop I.	−428488·8	+ 638426·5
Tafelkop (Ermelo)	−336449·2	+ 545557·3
Vlakfontein	−489806·4	+ 450665·4
Baatjes Bult	−400397·2	+ 412392·6
Tafelkop (Duivel's Kantoor)	−570429·5	+ 273011·7
Verloren Vlei	−360893·1	+ 124300·6
Wonderfontein	−292862·8	+ 293437·7
Panplaats	−251908·2	+ 245124·2
Groot Riet Vlei	−247881·5	+ 171784·1
Paardekop I.	−251592·9	+ 20400·3
Rhenosterkop I.	+ 17950·2	+ 214083·7
Quaggafontein	− 76317·1	− 41298·1
Zwartkloof	+276601·6	− 49163·1
Cable Hill	+273708·5	+ 251960·3
Boshofsberg	+452412·2	− 51108·2
Nooitgedacht I.	+482951·6	+ 315335·0
Observatory Hill (Johannesburg)	+302740·5	+ 431303·8
Blijvooruitzicht	+526447·6	+ 521751·9
Paardekop II.	+265359·1	+ 557134·4
Witkop II.	+495437·1	+ 657338·5
Elandskop I.	+317137·3	+ 797603·0
Vliegenkraal	+552576·8	+ 776222·9
Spitzkop II.	+321701·3	+ 881079·2

Origin ϕ_0 25°, L_0 − 26°.

	Eng. feet.	Eng. feet.
Breakfast Vlei	−291721·4	+2913579·1
Hogsback	−315645·4	+2702963·2
Bekruipkop	−454083·1	+2910256·2
Gonubie	−530896·8	+2774341·2
Windvogel Berg	−344622·5	+2655211·8
Mbulu	−527866·2	+2602704·7
Lubisi	−464304·7	+2466566·2
Cweceweni	−629159·6	+2504864·5
Xuka	−623357·7	+2295510·0
Waschbank Peak	−453826·2	+2277703·3
Bendearg	−619758·6	+2227013·0
Helvelyn	−400808·8	+2075588·5
Nthodimonate	−551467·2	+2000825·5
Aasvogel Berg	−332312·3	+1926620·4
Thaba Putsua	−609771·2	+1724551·9
Mabula	−403482·4	+1579259·4
Jammersberg	−325620·9	+1711815·5
Lemoenfontein	−126794·4	+1709181·7
Koesberg	−302873·4	+1916339·4
De Put	+ 3361·5	+1880102·7
Lokshoek	+131783·8	+1690282·4
Drie Baden	+180618·0	+1840922·8
Fauresmith Hill	+209225·9	+1725018·9
Luiper's Rand	+256306·6	+1793258·0
Platkop	+295861·1	+1674840·0
Wonderkloof	+412749·5	+1827770·4
Boschjes Pan	+452293·7	+1672808·1
Orange River	+551668·1	+1699948·4
Besterskop	+551280·4	+1886295·2
Elandsberg II.	+683356·5	+1771522·4
Loskop I.	+623257·4	+1635912·2
Eckmond	+587798·2	+1596728·6
Kolskop	+494510·1	+1544424·3
Leeuwberg	+663854·0	+1582277·6

Table L—*continued.*

FINAL CO-ORDINATES OF STATIONS IN CIRCUITS—*continued.*

Station.	Co-ordinates.	
	Y	X
Moller Pile	+570650·5	+1406773·8
Scholtz Kop	+419208·4	+1421301·4
Wolvedam	+464978·7	+1370103·8
Kimberley Hill	+415840·4	+1362294·9
Tarantal Kop	+352126·1	+1327565·4
Aasvogel Kop	+317690·2	+1356093·0
Boshof Hill	+265761·2	+1292488·1
Rondefontein	+208253·8	+1371870·7
Karreelaagte	+151491·1	+1300404·8
Du Plessis Dam	+170268·8	+1201312·4
Weltevreden	+ 65687·1	+1175459·9
Bosberg	− 27244·6	+1268994·0
Biesie Pan	− 40941·9	+1169271·9
Schoongezicht	−128625·8	+1208358·8
Zoetvlei	−116799·8	+1032901·5
Therons Kop	−251176·3	+1206480·4
Braunzijn Kop	−301846·1	+1037257·2
Nooitverwacht	−195188·5	+ 909280·0
Rhenosterkop II.	−384407·5	+ 882359·5
Boschrand	−380599·2	+ 997810·6
Doornkop	−442275·5	+ 957739·6
Vliegenkraal	−428268·4	+ 774678·7
Liebenberg Stroom	−567822·6	+ 957773·0
Kaffir Kop	−638485·4	+1134939·8
Rietfontein	−518454·1	+1066545·4
Mijnhardts Rust	−469863·6	+1129455·2
Zwartkrans	−646736·4	+1281538·5
Rhebokberg	−461141·9	+1404283·0
Machache	−603950·0	+1589173·7
Kameelpan II.	+334980·0	+1284328·1
Zwartkop I.	+267049·4	+1271152·3
Boesmanskop	+316253·6	+1220748·5
Uitkyk	+238968·2	+1184527·8
Leeuwlaagte	+305828·8	+1180661·6
Boomplaats	+208894·5	+1128087·1
Winterhoek	+260014·8	+1147025·6
Houtnek	+216748·0	+1075091·6
Bethel Pella	+277700·4	+1100166·9
Schoonheid	+289043·5	+1086106·7
Langvallei	+228568·6	+1029060·8
Never Mind	+268042·7	+ 984871·8
Kopje Enkel	+295100·7	+ 966890·8
Kameelpan I.	+266499·2	+ 958258·3
Smitskraal	+305884·3	+ 917994·4
Nooitgedacht II.	+277704·3	+ 906328·2
Amsterdam	+306608·1	+ 905116·0
Klipkuil	+317341·7	+ 828885·2
Doornhoek	+248774·5	+ 864615·7
Morgenzon	+241512·1	+ 772657·7
Holpan	+201858·5	+ 817746·0
Panfontein	+187969·7	+ 804517·8
Makouws Kop	+149759·4	+ 751329·5
Stroppan	+193725·4	+ 694083·1
Doornbult III.	+137089·6	+ 715817·5
Rosalio	+137560·5	+ 709481·3
Rietpan	+166584·6	+ 667914·1
Doornbult II.	+116271·5	+ 650987·8
Simonsvlei	+108974·9	+ 701389·6
Zwartsrust	+ 69045·7	+ 684974·8
Boschpan	+ 81487·1	+ 638345·7
Karreekuil	+ 16552·9	+ 660083·8
Disselboompan	+ 30960·2	+ 580240·1
Driekuil	− 13167·7	+ 639305·8
Middelbult	− 24400·1	+ 541451·2
Leeuwfontein	− 91301·9	+ 613070·6

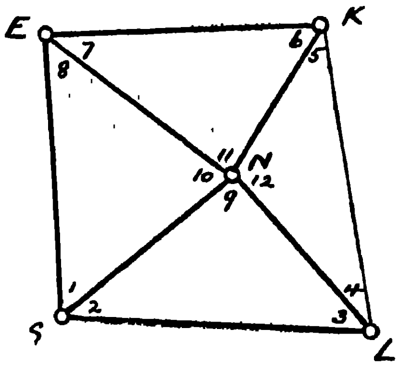
Table L—*concluded.*

FINAL CO-ORDINATES OF STATIONS IN CIRCUITS—*continued.*

Station.	Co-ordinates.	
	Y.	X.
	Eng. feet.	Eng. feet.
Schietfontein	− 74858·2	+ 681852·9
Rhenosterberg Hoek	−140826·2	+ 668402·1
Doornplaats	−144710·2	+ 785504·8
Klerksdorp	−221973·6	+ 682741·8
Vlaglaagte	−195884·6	+ 789131·0
Paradijs	−288764·6	+ 729015·9
Bovenlands Plaats	−275172·9	+ 830965·9
Spitzkop II.	−651562·2	+ 885058·2
Elandskop I.	−658129·9	+ 801684·5
Witkop II.	−483213·4	+ 657194·2
Paardekop II.	−715582·5	+ 562402·4
Blijvooruitzicht	−455391·3	+ 520923·6
Observatory Hill (Johannesburg)	−681136·3	+ 435677·5
Nooitgedacht I.	−503636·9	+ 315571·3
Cable Hill	−714267·9	+ 256963·4
Boshofsberg	−542383·8	− 50117·7
Pilandsberg	−852149·3	+ 64753·4
Tafelkop	−238516·6	+ 343613·0
Kaalkop I.	−235072·4	+ 208889·2
Onverwacht	− 83459·7	+ 244140·7
Enzelberg	− 72984·3	+ 152377·3
Vergenoeg	+ 2845·9	+ 209407·5
Witkop I.	− 11617·3	+ 274020·3
Klippan	+ 49534·8	+ 258385·5
Malopos Oog	− 10922·0	+ 314896·9
Grootfontein	+ 44118·7	+ 340394·5
Polfontein	+ 38100·0	+ 374069·7
De Paarl	+ 11035·4	+ 303821·7
Welvediend	− 66658·5	+ 358874·4
Houthaal Boomen	− 81186·5	+ 393958·8
Doornbult I.	− 28985·8	+ 479395·5
Bethlehem	+ 29229·8	+ 420580·6
Makoeies Pan	+ 48100·1	+ 475959·8

NON-CIRCUIT EQUATIONS.

Figure XVa.



E ... Kopje Enkel.
K ... Kameelpan I.
L ... Langvallei.
S ... Schoonheid.
N ... Never Mind.

Figural Angles.

	°	′	″
4 =	13	16	38·35
5 =	81	33	48·18
Fixed 12 =	135	9	33·76

Equations to be satisfied.

$$x_4 + x_5 \quad + 0\cdot08 = 0$$
$$-89\cdot2x_4 + 34\cdot3x_5 - 3\cdot7 = 0$$

Resulting Corrections.

$x_4 = -0\text{''}\cdot04$ $\qquad$ $x_5 = +0\text{''}\cdot01$

NON-CIRCUIT EQUATIONS—*continued.*

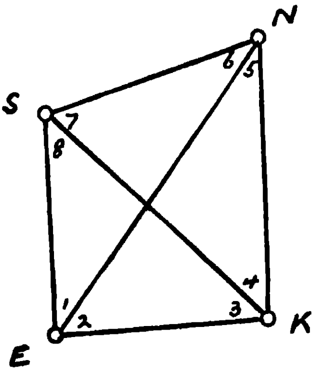


Figure XVIa.

S ... Smitskraal.
N ... Nooitgedacht II.
E ... Kopje Enkel.
K ... Kameelpan I.

Figural Angles.

	°	′	″		°	′	″
1 =	28	27	57·44	6 =	51	29	4·13
2 =	57	10	12·79	Fixed 7 =	68	6	49·48
Fixed 3 =	62	25	40·72	Fixed 8 =	81	56	9·41
Fixed 4 =	32	11	44·08	Fixed 1 + 2 =	85	38	10·22
5 =	28	12	22·72	Fixed 5 + 6 =	79	41	26·87

Equations to be satisfied.

$$x_1 + x_2 \qquad + 0{\cdot}01 = 0$$
$$x_5 + x_6 \qquad - 0{\cdot}02 = 0$$
$$x_2 + x_5 \qquad - 0{\cdot}07 = 0$$
$$- 38{\cdot}8x_1 + 16{\cdot}7x_6 - 1{\cdot}4 \quad = 0$$

Resulting Corrections.

″	″
$x_1 = - 0{\cdot}04$	$x_5 = + 0{\cdot}04$
$x_2 = + 0{\cdot}03$	$x_6 = - 0{\cdot}02$

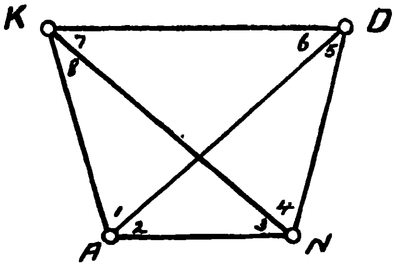


Figure XVIIa.

K ... Klipkuil.
D ... Doornhoek.
A ... Amsterdam.
N ... Nooitgedacht II.

Figural Angles.

	°	′	″		°	′	″
1 =	63	0	57·10	6 =	62	31	16·90
2 =	37	24	11·51	Fixed 7 =	35	22	18·97
Fixed 3 =	60	29	23·70	Fixed 8 =	19	5	28·22
Fixed 4 =	61	51	11·32	Fixed 1 + 2 =	100	25	8·60
5 =	20	15	13·69	Fixed 5 + 6 =	82	46	30·63

Equations to be satisfied.

$$x_1 + x_2 \qquad + 0{\cdot}01 = 0$$
$$x_5 + x_6 \qquad - 0{\cdot}04 = 0$$
$$x_2 + x_5 \qquad - 0{\cdot}07 = 0$$
$$11{\cdot}0x_6 - 10{\cdot}7x_1 + 0{\cdot}7 \quad = 0$$

Resulting Corrections.

″	″
$x_1 = + 0{\cdot}01$	$x_5 = + 0{\cdot}09$
$x_2 = - 0{\cdot}02$	$x_6 = - 0{\cdot}05$

Non-Circuit Equations—*continued.*

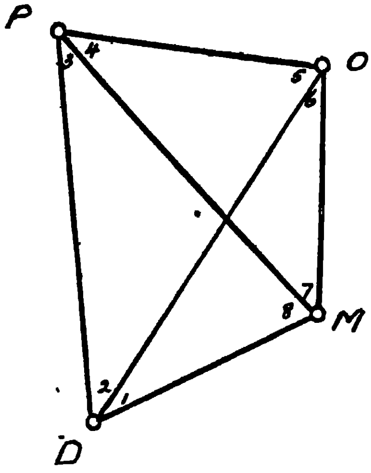


Figure XVIIIa.

P ... Makoeies Pan.
O ... Doornbult I.
M ... Middelbult.
D ... Disselboompan.

Figural Angles.

	°	′	″
1 =	26	23	54·38
2 =	37	55	5·35
Fixed 3 =	38	34	25·84
Fixed 4 =	39	21	49·32
5 =	64	8	40·51
6 =	28	58	0·02
Fixed 7 =	47	31	31·10
Fixed 8 =	77	6	35·98
Fixed 1 + 2 =	64	18	59·70
Fixed 5 + 6 =	93	6	40·64

Equations to be satisfied.

$$
\begin{aligned}
x_1 + x_2 \quad & + 0{\cdot}03 = 0 \\
x_5 + x_6 \quad & - 0{\cdot}11 = 0 \\
x_1 + x_6 \quad & + 0{\cdot}66 = 0 \\
+ 42{\cdot}4x_1 - 27{\cdot}0x_2 + 10{\cdot}2x_5 - 38{\cdot}0x_6 & + 2{\cdot}6 = 0
\end{aligned}
$$

Resulting Corrections.

$x_1 = -0{\cdot}31''$
$x_2 = +0{\cdot}28''$

$x_5 = +0{\cdot}46''$
$x_6 = -0{\cdot}35''$

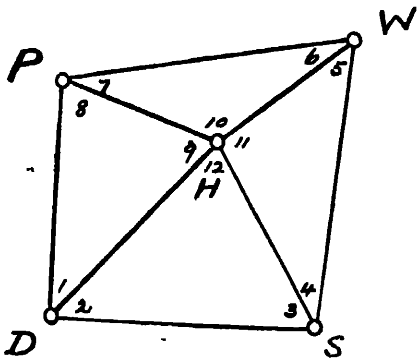


Figure XIXa.

P ... De Paarl.
W ... Welvediend.
S ... Sypherpan.
D ... Doornbult I.
H ... Houthaal Boomen.

Figural Angles.

	°	′	″		°	′	″
2 =	60	26	27·28	Fixed 9 =	85	22	5·00
3 =	59	25	12·58	Fixed 10 =	134	43	11·32
4 =	32	28	0·07	11 =	79	46	21·50
5 =	67	45	39·44	12 =	60	8	21·58

Equations to be satisfied.

$$
\begin{aligned}
x_2 + x_3 - x_{11} \quad & - 0{\cdot}08 = 0 \\
x_4 + x_5 + x_{11} \quad & = 0 \\
- 11{\cdot}9x_2 + 12{\cdot}4x_3 - 33{\cdot}1x_4 + 8{\cdot}6x_5 & + 50{\cdot}3 = 0
\end{aligned}
$$

Resulting Corrections.

$x_2 = +0{\cdot}39''$
$x_3 = -0{\cdot}58''$
$x_4 = +0{\cdot}98''$

$x_5 = -0{\cdot}71''$
$x_{11} = -0{\cdot}27''$

VERTICAL HEIGHTS.

17. The differences of height were computed by the formula Formula.

$$h' - h = s \, . \tan \tfrac{1}{2} (\alpha - \alpha')$$

where

s = the length of the line in feet

α, α' = the angles of elevation of each point from the other.

18. As in previous surveys in South Africa, weights were assigned to the observations in inverse proportion to the length of the lines. The heights were adjusted in blocks or sets as shown in the Diagram for Solution of Vertical Heights, Diagram No. 3. The heights of all stations in the Survey of Cape Colony and Natal have been taken as fixed by the original solution (G.S. Report, Vol. I, pp. 191–216). These are, therefore, the data for height in the present solution. Method of adjustment.

At the end of this paragraph are given :—

1. The coefficients of refraction and the mean coefficient for each chain Quantities in brackets are omitted in the mean (Table M).
2. The formation of the Equations of Condition.
3. The corrections to the observed differences of height (Table N).

Table M.

COEFFICIENTS OF REFRACTION DETERMINED FROM MUTUAL VERTICAL ANGLES.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.	Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.	Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
NEWCASTLE TO BELFAST.			NEWCASTLE TO BELFAST.—(*cont.*)			BELFAST TO OTTOSHOOP.		
57 — 59	·059	30·8	69 — 71	·057	55·1	80 — 82	·065	35·2
60 — 57	·059	33·6	70 — 71	·059	48·7	82 — 81	·066	51·6
59 — 60	·063	30·9	72 — 71	·064	34·5	82 — 83	·065	66·9
59 — 61	·062	25·5	72 — 73	·084	12·0	81 — 83	·064	69·9
60 — 61	·059	27·7	71 — 73	·067	30·8	81 — 84	·066	49·0
61 — 62	·064	25·9	73 — 75	·074	14·4	84 — 83	·061	57·0
60 — 62	·054	20·8	71 — 75	·067	20·4	83 — 85	·059	33·3
62 — 59	·062	43·6	71 — 74	·068	26·2	84 — 85	·061	66·6
61 — 63	·062	13·5	71 — 76	·070	17·5	84 — 86	·065	41·4
62 — 63	·066	29·8	76 — 75	·064	12·6	85 — 86	·059	69·6
61 — 64	·059	32·2	76 — 74	(·097)	(12·9)	85 — 87	·065	42·1
63 — 64	·061	23·9	75 — 74	(·096)	(7·7)	86 — 87	·062	55·5
62 — 65	·064	32·5	73 — 74	·073	17·9	86 — 88	·057	50·5
63 — 65	·059	24·7	75 — 78	·073	9·6	87 — 88	·061	57·0
63 — 66	·070	34·5	75 — 77	·083	6·4	88 — 89	·060	25·5
65 — 66	·062	24·8	78 — 76	·078	8·8	87 — 89	·064	35·1
63 — 64	·061	23·9	78 — 77	·068	11·8	87 — 91	·068	55·4
66 — 64	·051	32·8	76 — 77	·073	9·7	89 — 91	·068	32·7
64 — 67	·057	40·1	74 — 79	·068	25·2	89 — 90	·067	29·7
66 — 67	·071	11·7	75 — 79	·061	18·0	88 — 90	·068	34·9
67 — 69	·065	20·9	73 — 79	·077	13·9	91 — 90	·069	17·5
66 — 69	·055	28·0	71 — 79	·060	23·3	91 — 92	·068	25·8
66 — 68	·071	34·2	71 — 80	·064	28·6	91 — 93	·066	18·0
65 — 68	·060	37·4	79 — 80	·066	28·7	90 — 93	·074	17·6
68 — 69	·079	18·4	79 — 81	·066	50·9	93 — 92	·071	12·5
68 — 70	·068	36·9	73 — 81	·069	51·5	90 — 92	·067	14·7
69 — 70	·062	41·6	80 — 81	·065	62·9	92 — 95	(·028)	(4·9)
67 — 72	·064	36·9				92 — 94	·070	10·7
69 — 72	·065	30·4				93 — 94	·051	7·0
			Mean	·065	27·5	93 — 95	·078	15·1
						94 — 95	(·128)	(10·8)
						Mean	·065	37·9

Table M—*continued.*

COEFFICIENTS OF REFRACTION DETERMINED FROM MUTUAL VERTICAL ANGLES—*continued.*

PRETORIA TO KROONSTAD.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
84 — 96	·061	34·4
86 — 96	·064	40·6
86 — 97	·061	40·0
97 — 96	·055	45·7
97 — 98	·058	49·9
97 — 99	·054	26·3
96 — 98	·058	24·9
98 — 100	·058	46·6
98 — 99	·060	47·5
100 — 102	·057	15·8
100 — 101	·059	44·8
100 — 99	·060	43·0
99 — 101	·059	25·0
101 — 102	·060	48·0
101 — 103	·058	44·1
101 — 104	·053	34·9
101 — 105	·059	21·7
105 — 104	·064	18·0
105 — 109	·045	13·9
105 — 106	·057	21·9
105 — 107	·058	33·2
105 — 108	·059	15·0
109 — 106	(·036)	(8·6)
109 — 107	·058	23·6
109 — 108	·041	12·3
109 — 104	·051	8·9
108 — 104	·062	21·1
108 — 106	·044	14·1
108 — 107	·049	19·0
106 — 107	·056	16·7
106 — 104	·073	13·9
106 — 110	·061	29·2
104 — 103	·056	23·7
104 — 110	·056	25·2
103 — 102	·055	21·1
103 — 111	·058	22·7
103 — 112	·057	36·2
103 — 110	·055	22·6
102 — 111	·059	17·3
111 — 112	·059	32·7
112 — 110	·063	26·2
Mean	·057	28·0

KROONSTAD TO WEPENER.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
112 — 114	·055	27·8
112 — 113	·065	32·1
110 — 113	·055	15·1
113 — 114	·059	44·3
113 — 115	·056	52·1
114 — 115	·058	42·1
114 — 116	·057	58·8
115 — 116	·060	44·2
115 — 117	·057	34·9
116 — 117	·064	38·0
116 — 119	·061	41·2
116 — 118	·055	25·7
118 — 117	·060	47·8
118 — 119	·063	29·5
119 — 117	·059	38·5
117 — 120	·058	29·0

BELFAST TO OTTOSHOOP. (*cont.*)

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
119 — 120	·060	25·6
119 — 121	·062	11·2
119 — 124	·059	25·0
121 — 120	·063	18·5
121 — 122	·060	20·0
121 — 123	·060	13·8
121 — 124	·068	14·0
124 — 120	·058	20·0
124 — 122	·055	19·2
124 — 123	·049	5·8
120 — 123	·057	14·5
120 — 122	·055	3·2
122 — 123	·073	13·5
127 — 117	·057	67·1
127 — 118	·060	65·0
125 — 120	·068	37·7
125 — 124	·066	45·6
125 — 126	·066	51·4
126 — 120	·065	39·1
126 — 124	·067	20·5
126 — 127	·078	6·0
127 — 120	·063	40·8
127 — 124	·063	21·1
124 — 120	·065	20·0
Mean	·061	30·4

WEPENER TO CALA.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
127 — 128	·064	43·8
127 — 129	·051	31·1
128 — 130	·053	44·7
128 — 129	·059	31·9
128 — 118	·054	53·5
129 — 130	·054	50·4
129 — 131	·055	39·6
131 — 130	·056	32·9
131 — 10	·062	32·3
131 — 8	·065	35·8
130 — 10	·063	13·0
10 — 8	·066	44·2
Mean	·058	37·8

HOPETOWN TO WEPENER.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
134 — 135	·072	35·8
134 — 136	·074	19·5
134 — 133	·068	25·8
133 — 135	·070	26·3
135 — 136	·069	30·3
135 — 137	·068	36·5
135 — 140	·070	30·4
136 — 137	·071	29·6
137 — 139	·065	31·2
137 — 138	·066	19·0
137 — 140	·067	23·6
140 — 138	·063	15·7
140 — 141	·073	16·9
138 — 139	.065	16·1

WEPENER TO CALA. (*cont.*)

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
138 — 141	·062	22·6
139 — 125	·064	49·1
139 — 142	·060	43·4
139 — 141	·058	30·0
141 — 142	·060	34·4
142 — 125	·063	40·7
142 — 126	·067	58·3
Mean	·066	30·2

KROONSTAD TO KIMBERLEY.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
105 — 176	·070	36·2
176 — 107	·075	31·6
176 — 175	·078	27·7
107 — 174	·069	33·5
107 — 175	·072	35·1
175 — 174	·066	41·6
175 — 173	·065	33·3
175 — 172	·070	29·6
174 — 173	·069	23·2
174 — 172	·066	40·4
173 — 172	·072	18·2
173 — 170	·067	21·9
172 — 170	·067	18·1
172 — 171	·073	20·2
170 — 168	·068	34·5
170 — 171	·065	24·3
171 — 168	·066	28·7
171 — 169	·084	20·4
168 — 164	·068	17·3
168 — 165	·071	21·7
168 — 169	·071	19·1
169 — 165	·062	25·0
165 — 164	·064	18·6
165 — 162	·065	15·6
165 — 152	·065	17·7
164 — 163	·067	21·2
164 — 162	·066	20·9
162 — 152	·062	8·5
162 — 163	·067	17·7
162 — 149	·064	22·9
152 — 149	·064	21·8
163 — 149	·065	24·5
Mean.	·068	24·7

NEWCASTLE TO KROONSTAD.

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
57 — 58	·068	23·1
59 — 58	·062	23·8
59 — 182	·058	25·1
58 — 181	·055	22·3
58 — 182	·058	31·1
182 — 180	·062	24·6
182 — 181	·058	20·9
181 — 179	·058	28·3
181 — 180	·057	21·2
180 — 179	·060	24·3
180 — 178	·063	29·7

Table M—*concluded.*

COEFFICIENTS OF REFRACTION DETERMINED FROM MUTUAL VERTICAL ANGLES—*continued.*

Numbers of Stations.	Coefficients of Refraction.	Distance in Miles.
PRETORIA TO KROONSTAD.(*cont.*)		
179 — 177	·060	38·1
179 — 178	·060	31·8
178 — 177	·059	37·7
178 — 111	·062	28·6
177 — 111	·059	46·5
177 — 112	·058	32·9
Mean . . .	·060	28·5
KIMBERLEY TO OTTOSHOOP.		
152 — 167	·059	8·8
152 — 166	·060	7·2
162 — 166	·065	8·4
167 — 184	·059	12·6
167 — 183	·062	13·1
167 — 165	·066	13·2
167 — 166	·062	6·1
166 — 165	·063	10·5
165 — 183	·088	4·1
183 — 184	·050	13·4
183 — 185	·059	17·3
184 — 186	·070	7·9
186 — 187	·058	10·8
186 — 185	·062	12·7
184 — 185	·060	16·2
185 — 187	·070	8·2
185 — 188	·061	12·1
187 — 190	·068	9·5
187 — 189	·065	15·9
187 — 188	·059	10·3
190 — 191	(·098)	(12·3)
190 — 189	·082	12·5
189 — 191	·084	15·6
188 — 189	·053	10·2
189 — 192	·045	9·0
192 — 191	·084	11·5
192 — 193	·059	11·3
192 — 195	·059	15·2
191 — 194	·061	13·2
191 — 193	·046	10·6
193 — 194	·052	6·1
193 — 195	(·036)	(5·0)
195 — 194	·056	5·7
195 — 196	·067	10·7
195 — 197	·053	10·1
194 — 196	·046	9·5
194 — 197	·042	11·9
196 — 198	·056	2·4
196 — 197	·068	5·8
198 — 199	·055	14·6
198 — 200	(·101)	(13·4)
198 — 197	·066	5·5
197 — 199	·064	16·5
197 — 200	(·122)	(9·6)
201 — 200	·050	12·6
201 — 202	·068	11·4
201 — 203	(·014)	(3·6)
203 — 202	·060	11·8
203 — 204	·049	12·4
KIMBERLEY TO OTTOSHOOP (*cont.*).		
202 — 200	·082	17·5
202 — 199	·067	17·9
202 — 205	·082	17·4
202 — 204	·071	17·8
199 — 200	·088	14·6
204 — 205	·050	13·7
206 — 204	·042	7·1
206 — 205	(·025)	(11·5)
206 — 207	(·102)	(1·2)
205 — 208	·059	7·2
205 — 207	·045	11·0
207 — 208	·068	9·6
207 — 209	·070	11·8
207 — 210	(·101)	5·6
208 — 209	·071	10·1
209 — 210	·086	9·7
209 — 212	·045	7·0
209 — 211	(·028)	(11·0)
210 — 211	·069	8·2
211 — 212	·046	9·1
211 — 213	(·035)	(11·0)
212 — 213	·049	13·0
212 — 214	(·021)	(14·6)
213 — 214	·041	15·4
213 — 215	·046	6·9
215 — 216	·052	18·7
214 — 215	·044	14·0
214 — 217	·062	20·0
214 — 218	·070	21·8
214 — 216	(·030)	(12·8)
216 — 217	·041	18·5
216 — 218	(·036)	(11·8)
217 — 218	(·038)	(13·7)
217 — 219	(·012)	(11·1)
218 — 219	(·022)	(15·0)
218 — 220	·065	17·5
218 — 221	·067	16·2
218 — 222	·056	16·4
222 — 221	·065	16·4
222 — 223	·060	17·5
221 — 220	(·004)	(8·0)
221 — 223	·045	9·5
223 — 220	·048	16·2
223 — 224	·055	13·4
220 — 219	(·100)	(6·1)
220 — 225	·085	6·4
220 — 224	·054	15·5
225 — 226	·058	6·5
225 — 224	(·037)	(14·6)
226 — 227	·041	15·6
226 — 92	·048	16·4
226 — 224	(·035)	(11·5)
224 — 227	·047	15·7
227 — 93	·060	12·8
224 — 92	·062	7·7
92 — 227	·057	12·0
92 — 93	·083	12·5
Mean . . .	·060	12·1
TIE CHAIN THROUGH KLERKSDORP TO KROONSTAD.		
216 — 228	·051	18·6
215 — 228	·065	15·6
215 — 229	·049	14·2
228 — 229	·075	13·4
228 — 230	·071	15·3
230 — 229	·071	14·4
230 — 232	·072	18·9
230 — 231	·078	12·8
229 — 231	·061	16·7
231 — 232	·068	17·7
231 — 233	·086	14·0
232 — 234	·061	15·4
232 — 233	·051	20·7
233 — 234	·060	21·0
233 — 235	·056	17·0
233 — 176	·057	22·8
234 — 235	·054	19·5
235 — 176	·068	21·2
235 — 105	·069	22·9
Mean . . .	·064	17·2
LIMPOPO TO BELFAST.		
250 — 251	·065	33·6
250 — 248	·065	55·7
250 — 247	·065	57·3
250 — 249	·065	45·4
251 — 248	·061	55·6
249 — 248	·064	49·9
249 — 247	·065	28·3
247 — 248	·064	28·2
247 — 243	·057	36·0
247 — 242	·057	48·9
248 — 241	·058	62·7
248 — 243	·058	32·8
243 — 246	·072	5·7
243 — 245	·063	26·5
243 — 242	·064	29·0
243 — 244	·064	7·5
243 — 241	·062	44·6
244 — 246	·048	10·6
244 — 245	·060	27·6
244 — 242	·058	26·0
246 — 245	·052	21·1
246 — 242	·058	25·5
245 — 242	·058	15·1
242 — 241	·060	59·8
242 — 240	·055	30·9
240 — 241	·059	51·6
240 — 239	·058	46·0
240 — 237	·059	63·4
241 — 239	(·117)	(18·9)
239 — 238	·062	54·8
239 — 237	·056	50·4
238 — 236	·053	44·1
238 — 237	·060	43·6
237 — 236	·057	45·1
237 — 71	·056	42·3
236 — 70	·063	45·6
236 — 71	·055	39·1
Mean . . .	·060	38·6

Figures given in brackets are not included in the Mean.

FORMATION OF EQUATIONS OF CONDITION.

No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.
FIGURE BETWEEN RHENOSTER KOP I. AND BELFAST.—A.											
35	74—75	+ 5·3	2·6	37	75—76	− 271·9	4·2	32	75—71	−1109·6	6·8
37	75—76	−271·9	4·2	39	76—71	− 836·7	5·8	35	74—75	+ 5·3	2·6
36	74—76	−271.7	4·8	32	75—71	−1109·6	6·8	38	74—71	−1109·0	8·7
35+37—36+5·1=0				37+39—32+1·00=0				32+35—38+4·7=0			
31	73—71	−1695·6	10·3	33	75—73	+575·2	4·8	35	74—75	+ 5·3	2·6
34	74—73	+ 573·0	6·0	35	74—75	+ 5·3	2·6	40	79—74	−344·6	8·4
38	74—71	−1109·0	8·7	34	74—73	+573·0	6·0	41	79—75	−347·2	6·0
31+31—38—13·6=0				33+35—34+7·5=0				35+40—41+7·9=0			
33	95—73	+575·2	4·8	31	73—71	−1695·6	10·3	43	79—71	−1458·0	7·8
41	79—75	−347·2	6·0	42	79—73	+ 229·2	4·6	45	80—79	+ 222·4	9·6
42	79—73	+229·2	4·6	43	79—71	−1458·0	7·8	44	80—71	−1235·9	9·5
33+41—42—1·2=0				31+42—43—8·4=0				43+45—44+0·3=0			
45	80—79	+222·4	9·6	42	79—73	+229·2	4·6				
48	81—80	—699·2	21·3	46	81—79	—468·8	17·0				
46	81—79	—468·8	17·0	47	81—73	—225·9	17·2				
45+48—46—13·1=0				42+46—47—8·7=0							
BELFAST BASE QUADRILATERAL.—B.											
1	78—75	+261·7	3·2	2	76—78	+ 7·8	2·9	1	78—75	+261·7	3·2
5	77—78	—213·8	3·9	3	77—76	—222·9	3·2	2	76—78	+ 7·8	2·9
4	77—75	+ 49·0	2·1	5	77—78	—213·8	3·9	6	75—76	—273·8	Fixed
1+5—4—1·1=0				2+3—5—1·3=0				1+2—4·3=0			
FIGURE BETWEEN VERLOREN VLEI AND HLAMIMPESI BERG.—C.											
22	69—67	+ 62·0	7·0	24	72—69	— 177·6	10·1	26	70—69	+ 67·7	13·9
24	72—69	—177·6	10·1	29	71—72	+1572·6	11·5	28	71—70	+1323·5	16·2
23	72—67	—118·1	12·3	25	71—69	+1392·0	18·4	25	71—69	+1392·0	18·4
22+24—23+2·5=0				24+29—25+3·0=0				26+28—25—0·8=0			
21	69—68	+212·9	6·1	19	68—66	—155·6	11·4	17	67—66	— 7·5	8·9
26	70—69	+ 67·7	13·9	21	69—68	+212·9	6·1	22	69—67	+62·0	7·0
27	70—68	+271·9	12·3	18	69—66	+ 44·0	9·3	18	69—66	+44·0	9·3
21+26—27+8·7=0				19+21—18+13·3=0				17+22—18+10·5=0			
15	64—66	—145·2	10·9	13	66—63	—286·2	11·5	12	65—63	—295·4	8·2
16	67—64	+112·8	13·4	10	63—64	+398·0	8·0	13	66—63	—286·2	11·5
17	67—66	— 7·5	8·9	15	64—66	—145·2	10·9	14	66—65	+ 17·1	8·3
15+16—17—24·9=0				13+10+15—33·4=0				12—13+14+7·9=0			
19	68—66	—155·6	11·4	7	63—61	—360·6	4·5	4	61—62	— 779·8	8·6
14	66—65	+ 17·1	8·3	9	61—64	+757·7	10·7	7	63—61	— 360·6	4·5
20	68—65	—133·8	12·5	10	63—64	+398·0	8·0	8	63—62	—1139·8	9·9
19+14—20—4·7=0				7+9—10—0·9=0				4+7—8—0·6=0			
8	63—62	—1139·8	9·9								
11	65—62	—1436·4	10·8								
12	65—63	— 295·4	8·2								
8—11+12+1·2=0											
FIGURE BETWEEN HLAMIMPESI BERG AND SALT LAKE.—D.											
1	60—59	+ 655·1	10·3	1	60—59	+655·1	10·3	3	61—60	—814·0	9·2
0	60—57	+2851·4	11·2	2	61—59	—162·1	8·5	4	62—61	+780·7	Fixed
a	59—57	+2192·3	Fixed	3	61—60	—814·0	9·2	5	62—60	— 36·4	6·9
—0—4·0=0				1—2+3+3·2=0				3—5+3·1=0			
2	—59	—162·1	8·5								
4	62—61	+780·7	Fixed								
6	59—62	—608·8	14·5								
2+6+9·8=0											

FORMATION OF EQUATIONS OF CONDITION—*continued.*

FIGURE BETWEEN OTTOSHOOP AND PILANDSBERG.—E.

No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.
62	88—87	+155·5	19·0	64	89—87	—635·3	11·7	66	91—89	+ 28·9	10·8
63	89—88	—779·6	8·5	65	91—87	—598·6	18·4	67	90—89	+215·5	9·9
64	89—87	—635·3	11·7	66	91—89	+ 28·9	10·8	69	90—91	+187·6	5·8
	62+63—64+11·2=0				64+66—65—7·8=0				66+69—67+1·0=0		
63	89—88	—779·6	8·5	72	93—90	—287·1	5·9	69	90—91	+187·6	5·8
67	90—89	+215·5	9·9	73	92—93	+168·0	4·2	71	93—91	— 99·6	6·0
68	90—88	—571·1	11·6	74	92—90	—120·9	4·9	72	93—90	—287·1	5·9
	63+67—68+7·0=0				72+73—74+1·8=				69+72—71+ 0·1=0		
69	90—91	+187·6	5·8	73	92—93	+168·0	4·2	77	94—93	—131·5	2·8
70	92—91	+ 69·4	8·6	75	95—92	—250·7	1·6	78	95—93	— 83·8	5·0
74	92—90	—120·9	4·9	78	95—93	— 83·8	5·0	79	95—94	+ 38·7	3·6
	69+74—70—2·7=0				73+75—78+1·1=0				77+79—78—9·0=0		
73	92—93	+168·0	4·2								
77	94—93	—131·5	2·8								
76	94—92	—296·9	8·5								
	73+76—77+2·6=0										

KROONSTAD BASE FIGURE.—F.

No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.
15	102—101	+541·5	16·0	18	104—101	—182·4	11·6	18	104—101	—182·4	11·6
16	103—101	+331·4	14·7	16	103—101	+331·4	14·7	19	105—101	—109·3	7·2
17	102—103	+216·3	7·0	20	103—104	+522·6	7·9	21	104—105	— 90·3	6·0
	16+17—15+6·2=0				18+20—16+8·8=0				19+21—18—17·2=0		
21	104—105	— 90·3	6·0	22	109—105	—238·4	4·6	23	108—105	—239·9	5·0
22	109—105	—238·4	4·6	23	108—105	—239·9	5·0	27	107—108	+123·5	6·3
26	104—109	+152·2	3·0	24	108—109	0·0	4·1	28	107—105	—114·0	11·1
	22+26—21+4·1=0				22+24—23+1·5=0				23+27—28—2·4=0		
26	104—109	+152·2	3·0	24	108—109	0·0	4·1	27	107—108	+123·5	6·3
30	106—109	+ 60·9	2·9	30	106—109	+60·9	2·9	31	107—106	+ 62·3	5·6
32	104—106	+ 89·5	4·6	42	106—108	+60·8	4·7	42	106—108	+ 60·8	4·7
	30+32—26—1·8=0				30—24—42+0·1=0				31+42—27—0·4=0		
30	106—109	+ 60·9	2·9	25	104—108	+146·2	7·0	29	106—105	—178·1	7·8
31	107—106	+ 62·3	5·6	32	104—106	+ 89·5	4·6	21	104—105	— 90·3	6·0
41	107—109	+123·1	7·9	42	106—108	+ 60·8	4·7	32	104—106	+ 89·5	4·6
	30+31—41+0·1=0				32+42—25+4·1=0				29+32—21+1·7=0		
20	103—104	+522·6	7·9	32	104—106	+ 89·5	4·6	17	102—103	+216·3	7·0
34	110—104	+397·6	8·4	33	110—106	+500·7	9·7	39	109—103	+419·5	7·6
35	110—103	—129·8	7·5	34	110—104	+397·6	8·4	40	109—102	+201·1	5·7
	20+35—34—4·8=0				32+34—33—13·6=0				17+40—39—2·1=0		
37	112—103	+606·1	12·1	35	110—103	—129·8	7·5				
38	112—109	+196·9	10·9	36	112—110	+738·7	8·7				
39	109—103	+419·5	7·6	37	112—103	+606·1	12·1				
	38+39—37+10·3=0				35+36—37+2·8=0						

FIGURE BETWEEN PILANDSBERG, RHENOSTERKOP I. AND SPITZKOP II.—G.

No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.
48	81—80	— 688·7	Fixed	50	81—82	+1790·3	17·2	52	83—81	—594·9	23·8
49	82—80	—2478·5	11·7	51	83—82	+1206·6	22·8	53	84—81	—694·4	16·8
50	81—82	+1790·3	17·2	52	83—81	— 594·9	23·8	54	83—84	+ 85·4	19·0
	49+50+0·5=0				50+52—51—11·2=0				53+54—52—14·1=0		
54	83—84	+ 85·4	19·0	56	85—84	+ 527·9	22·2	58	86—85	+715·6	23·2
55	85—83	+439·0	11·1	57	86—84	+1228·7	18·8	59	87—85	+152·4	14·0
56	85—84	+527·9	22·2	58	86—85	+ 715·6	23·2	60	87—86	—556·1	18·5
	54+55—56—3·5=0				56+58—57+14·8=0				58+60—59+7·1=0		

FORMATION OF EQUATIONS OF CONDITION—*continued.*

FIGURE BETWEEN PILANDSBERG, RHENOSTERKOP I, AND SPITZKOP II.—G—*continued.*

No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$
60	87—86	−556·1	18·5	57	86—84	+1228·7	13·8	4	97—86	−319·5	13·3
61	88—86	−405·2	16·8	3	96—86	− 143·4	13·5	5	96—97	+173·7	15·2
62	88—87	+152·5	Fixed	2	96—84	+1078·9	11·5	3	96—86	−143·4	13·5
	60—61+1·6=0				57+3—2+6·4=0				4+5—3—2·4=0		
5	96—97	+173·7	15·2	7	98—97	+397·9	16·6	10	100— 98	−775·7	15·5
6	98—96	+217·0	8·3	9	99—98	−610·8	15·8	11	99—100	+160·0	14·3
7	98—97	+397·9	16·6	8	99—97	−221·8	8·8	9	99— 98	−610·8	15·8
	5+6—7—7·2=0				7+9—8+8·9=0				10+11—9—4·9=0		
11	99—100	+160·0	14·3	13	101—100	−339·3	14·9				
12	101— 99	−497·7	8·3	14	102—100	+209·5	5·3				
13	101—100	−339·3	14·9	15	102—101	+547·1	Fixed				
	11+12—13+1·6=0				13—14—1·7=0						

FIGURE BETWEEN INKWELO AND KAFFIR KOP.—II.

No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$
5	59—58	+126·5	Fixed	8	182— 58	+189·6	10·4	9	182—180	+ 488·5	8·2
8	182—58	+189·6	10·4	7	181— 58.	+982·5	7·4	12	181—180	+1281·6	7·1
6	182—59	+ 58·7	8·4	10	181—182	+794·0	7·0	10	181—182	+ 794·0	7·0
	6—8—4·4=0				8+10—7+1·1=0				9+10—12+0·9=0		
12	181—180	+1281·6	7·1	13	180—179	+318·8	8·1	15	177—179	+460·2	12·7
11	181—179	+1599·1	7·8	14	180—178	+562·6	9·9	17	177—178	+702·9	12·6
13	180—179	+ 318·8	8·1	16	179—178	+244·4	10·6	16	179—178	+244·4	10·6
	12+13—11+1·3=0				13+16—14+0·6=0				15+16—17+1·7=0		
17	177—178	+702·9	12·6	20	177—112	+546·3	11·0	6	182— 59	+ 58·7	8·4
19	177—111	+741·9	15·5	19	177—111	+741·9	15·5	9	182—180	+488·5	8·2
18	178—111	+ 39·9	9·5	21	112—111	+194·6	Fixed	14	180—178	+562·6	9·9
								18	178—111	+ 39·9	9·5
	17+18—19+0·9=0				20—19—1·0=0				—6+9+14+18+9·1=0		

WEPENER BASE FIGURE—I.

No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$
15	120—119	−1895·8	8·5	18	120—121	−1233·6	6·2	26	122—120	− 891·3	1·1
22	120—124	− 181·2	6·7	22	120—124	− 181·2	6·7	22	120—124	− 181·2	6·7
17	124—119	−1716·6	8·3	21	124—121	−1051·9	4·6	23	122—124	−1072·5	6·4
	22+17—15—2·0=0				22+21—18+0·5=0				26+22—23+0·0=0		
23	122—124	−1072·5	6·4	26	122—120	−891·3	1·1	18	120—121	−1233·6	6·2
27	123—122	+ 445·8	4·5	25	123—120	−441·2	4·8	25	123—120	− 441·2	4·8
24	123—124	− 621·6	1·9	27	123—122	+445·8	4·5	20	123—121	−1674·6	4·0
	23+27—24—5·1=0				26+27—25—4·3=0				18+25—20—0·2=0		
18	120—121	−1233·6	6·2	15	120—119	−1895·8	8·5				
19	122—121	−2125·0	6·6	16	121—119	− 663·3	3·7				
26	122—120	− 891·3	1·1	18	120—121	−1233·6	6·2				
	18+26—19+0·1=0				16+18—15—1·1=0						

FIGURE BETWEEN KAFFIR KOP AND WEPENER.—J.

No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$	No.	Stations.	Difference of Height.	$\frac{1}{W}$
1	113—112	−795·3	10·7	1	113—112	− 795·3	10·7	3	114—113	+2505·8	14·8
2	113—110	− 55·7	5·0	3	114—113	+2505·8	14·8	4	115—113	+ 988·8	17·4
86	112—110	+736·9	Fixed	9	114—112	+1709·5	9·3	5	115—114	−1513·8	14·0
	1—2—2·7=0				1+3—9+1·0=0				3+5—4+3·2=0		
5	115—114	−1513·8	14·0	7	116—115	+3290·9	14·7	9	117—116	−2781·4	12·7
6	116—114	+1782·8	19·6	8	117—115	+ 514·4	11·6	10	119—116	−1880·7	18·7
7	116—115	+3290·9	14·7	9	117—116	−2781·4	12·7	14	117—119	− 903·4	11·2
	5+7—6—5·7=0				7+9—8—4·9=0				10+14—9—2·7=0		
10	119—116	−1880·7	18·7	12	117—118	−3469·6	15·9	14	117—119	− 903·4	11·2
11	118—116	+ 682·9	8·6	13	119—118	−2570·7	9·8	14A	120—117	− 993·8	9·7
13	119—118	−2570·7	9·8	14	117—119	− 903·4	11·2	15	120—119	−1896·3	Fixed
	11+13—10—7·1=0				13+14—12—4·5=0				14+14*a*—0·9=0		

Formation of Equations of Condition—*continued.*

No.	Station.	Difference of Height.	1/W	No.	Station.	Difference of Height.	1/W	No.	Station.	Difference of Height.	1/W
Figure between Mabula and Lubisi.—K.											
0	117—118	—3469·0	Fixed	2	118—127	+2897·6	21·7	3	128—127	+1583·6	14·6
1	117—127	— 563·7	22·4	3	128—127	+1583·6	14·6	4	129—127	+ 907·8	10·4
2	118—127	+2897·6	21·7	7	118—128	+1325·8	17·8	6	129—128	— 674·1	10·6
	2—1—7·7=0				3+7—2+11·8=0				3+6—4+1·7=0		
5	130—128	+253·7	14·9	8	130—129	+937·0	16·8	10	130—131	+ 663·7	11·0
6	129—128	—674·1	10·6	9	131—129	+271·9	13·2	11	10—131	—2208·4	10·8
8	130—129	+937·0	16·8	10	130—131	+663·7	11·0	13	10—130	—2867·4	4·3
	6+8—5+9·2=0				9+10—8—1·4=0				10+13—11+4·7=0		
11	10—131	—2208·4	10·8	1	117—127	— 563·7	22·4				
12	8—131	—2621·3	11·9	4	129—127	+ 907·8	10·4				
15	8— 10	— 389·0	Fixed	9	131—129	+ 271·9	13·2				
				12	8—131	—2621·3	11·9				
	11—12+23·9=0				1—4—9—12+12·7=0						
Chain—Hope Town to Wepener.—L.											
1	135—134	+951·3	11·9	1	135—134	+951·3	11·9	5	13—135	—343·6	10·1
3	133—134	+891·6	Fixed	2	136—134	+603·9	6·5	6	137—135	— 5·6	12·2
4	135—133	+ 47·5	8·8	5	136—135	—343·6	10·1	8	137—136	+339·6	9·9
	4—1—12·2=0				5+1—2+3·8=0				5+8—6+1·6=0		
6	137—135	— 5·6	12·2	10	138—137	+317·0	6·3	9	139—137	+175·4	10·4
7	140—135	+564·6	10·1	11	140—137	+569·7	7·9	10	138—137	+317·0	6·3
11	140—137	+569·7	7·9	12	138—140	—252·7	5·2	14	139—138	—141·8	5·4
	6+11—7—0·5=0				11+12—10=0				10+14—9—0·2=0		
12	138—140	—252·7	5·2	14	139—138	—141·8	5·4	17	142—139	+454·0	14·5
13	141—140	+383·8	5·7	15	141—138	+635·5	7·5	18	141—139	+779·9	10·0
15	141—138	+635·5	7·5	18	141—139	+779·9	10·0	19	142—141	—325·2	11·5
	12+15—13—1·0=0				14+18—15+2·6=0				18+19—17+0·7=0		
16	125—139	+890·3	16·4	20	125—142	+ 435·9	13·6	23	124—125	— 30·6	15·2
17	142—139	+454·0	14·5	21	126—142	+1351·8	19·4	24	126—125	+911·0	17·1
20	125—142	+435·9	13·6	24	126—125	+ 911·0	17·1	26	124—126	—942·0	6·8
	17+20—16—0·4=0				20+24—21—4·9=0				24+26—23—0·4=0		
22	120—125	—209·2	12·6	25	120—126	—1124·6	13·0	26	124—126	—942·0	6·8
23	124—125	— 30·6	15·2	26	124—126	— 942·0	6·8	27	127—126	+438·8	2·0
30	120—124	—180·3	Fixed	30	120—124	— 180·3	Fixed	29	124—127	—1376·9	Fixed
	23—22—1·7=0				26—25+2·3=0				27—26+3·9=0		
2	136—134	+603·9	6·5								
8	137—136	+339·6	9·9								
9	139—137	+175·4	10·4								
16	125—139	+890·3	16·4								
22	120—125	—209·2	12·6								
	2+8+9+16+22—0·6=0										
Chain—Kroonstad to Kimberley.—M.											
1	107—105	—115·4	Fixed	2	176—105	—515·6	12·1	5	107—176	+390·5	10·5
2	176—105	—515·6	12·1	3	235—105	—389·8	7·6	6	175—176	—103·6	9·2
5	107—176	+390·5	10·5	4	235—176	+123·7	7·1	8	175—107	—493·6	11·7
	2+5—9·7=0				2+4—3—2·1=0				5+8—6+0·5=0		
7	174—107	+368·7	11·2	9	174—175	+859·9	13·9	10	173—175	+339·3	11·1
8	175—107	—493·6	11·7	10	173—175	+339·3	11·1	11	172—175	+209·9	9·9
9	174—175	+859·9	13·9	12	173—174	—519·6	7·7	14	172—173	—127·8	6·1
	8+9—7—2·4=0				9+12—10+1·0=0				10+14—11+1·6=0		
12	173—174	—519·6	7·7	14	172—173	—127·8	6·1	16	170—172	+232·0	6·0
13	172—174	—652·1	13·5	15	170—173	+104·0	7·3	17	171—172	— 10·1	6·7
14	172—173	—127·8	6·1	16	170—172	+232·0	6·0	19	171—170	—240·8	8·1
	12+14—13+4·7=0				14+16—15+0·2=0				16+19—17+1·3=0		

FORMATION OF EQUATIONS OF CONDITION—*continued.*

CHAIN—KROONSTAD TO KIMBERLEY.—M—*continued.*

No.	Station.	Difference of Height.	$\frac{1}{W}$.	No.	Station.	Difference of Height.	$\frac{1}{W}$.	No.	Station.	Difference of Height.	$\frac{1}{W}$.
18	168—170	−341·4	11·5	20	168—171	−101·8	9·6	23	165—168	− 76·9	7·2
19	171—170	−240·8	8·1	21	169—171	+ 2·1	6·8	24	169—168	+ 90·0	6·4
20	168—171	−101·8	9·6	24	169—168	+ 90·0	6·4	25	165—169	−172·2	8·3
	19+20—18—1·2=0				20+24—21—13·9=0				24+25—23—5·3=0		
22	164—168	+ 67·7	5·8	26	164—165	+146·4	6·2	29	163—164	−344·7	7·1
23	165—168	− 76·9	7·2	27	162—165	+302·7	5·2	30	162—164	+157·1	7·0
26	164—165	+146·4	6·2	30	162—164	+157·1	7·0	32	163—162	−502·8	5·9
	23+26—22+1·8=0				26+30—27+0·8=0				30+32—29—1·0=0		
32	163—162	−502·8	5·9	27	162—165	+302·7	5·2	31	152—162	−322·9	2·8
33	149—162	−457·4	7·6	28	152—165	− 19·4	5·9	33	149—162	−457·4	7·6
35	149—163	+ 42·3	14·1	31	152—162	−322·9	2·8	34	149—152	−130·3	Fixed
	32+35—33—3·1=0				27+31—28—0·8=0				31—33+4·2=0		
28	152—165	− 19·4	5·9								
25	165—169	−172·2	8·3								
21	169—171	+ 2·1	6·8								
17	171—172	− 10·1	6·7								
11	172—175	+209·9	9·9								
8	175—107	−493·6	11·7								
28+25+21+17+11+8+23·7=0											

CHAINS BETWEEN KIMBERLEY, OTTOSHOOP, AND KROONSTAD.—N.

No.	Station.	Difference of Height.	$\frac{1}{W}$.	No.	Station.	Difference of Height.	$\frac{1}{W}$.	No.	Station.	Difference of Height.	$\frac{1}{W}$.
1	152—162	−325·2	Fixed	2	166—162	−351·6	2·8	4	167—152	−342·0	2·9
2	166—162	−351·6	2·8	3	162—165	+302·1	Fixed	5	166—152	− 29·1	2·4
5	166—152	− 29·1	2·4	10	165—166	+ 48·3	3·5	9	166—167	+321·7	2·0
	5—2—2·7=0				2+10—1·2=0				4+9—5+8·8=0		
8	165—167	+370·8	4·4	7	183—167	+216·6	4·4	6	184—167	+138·3	4·2
9	166—167	+321·7	2·0	8	165—167	+370·8	4·4	7	183—167	+216·6	4·4
10	165—166	+ 48·3	3·5	11	183—165	−154·0	1·4	12	184—183	− 76·8	4·5
	9+10—8—0·8=0				8+11—7+0·2=0				7+12—6+1·5=0		
12	184—183	− 76·8	4·5	14	186—184	+244·4	2·6	16	187—186	− 27·5	3·6
13	185—183	+479·6	5·8	15	185—184	+555·8	5·4	17	185—186	+310·7	4·2
15	185—184	+555·8	5·4	17	185—186	+310·7	4·2	18	187—185	−338·0	2·7
	12+15—13—0·6=0				14+17—15—0·7=0				17+18—16+0·2=0		
18	187—185	−338·0	2·7	21	189—187	−122·3	5.3	20	190—187	−332·9	3·2
19	188—185	−450·0	4·0	22	188—187	−111·8	3·4	21	189—187	−122·3	5·3
22	188—187	−111·8	3·4	25	189—188	− 9·1	3·4	24	189—190	+213·1	4·2
	18+22—19+0·2=0				22+25—21+1·4=0				20+24—21+2·5=0		
23	191—190	+130·2	4·1	26	191—189	−84·0	5·2	28	191—192	− 30·7	3·8
24	189—190	+213·1	4·2	27	192—189	−50·2	3·0	29	193—192	+ 79·0	3·8
26	191—189	− 84·0	5·2	28	191—192	−30·7	3·8	32	193—191	+104·5	3·5
	24+26—23—1·1=0				27+28—26+3·1=0				28+32—29—5·2=0		
31	194—191	+198·1	4·4	29	193—192	+ 79·0	3·8	33	194—193	+92·0	2·0
32	193—191	+104·5	3·5	30	195—192	+179·0	5·1	34	195—193	+99·6	1·7
33	194—193	+ 92·0	2·0	34	195—193	+ 99·6	1·7	35	194—195	− 7·7	1·9
	32+33—31—1·6=0				29+34—30—0·4=0				34+35—33—0·1=0		
35	194—195	− 7·7	1·9	36	196—195	+ 95·7	3·6	37	196—194	+101·4	3·2
36	196—195	+ 95·7	3·6	36A	197—195	+105·2	3·4	38	197—194	+112·1	4·0
37	196—194	+101·4	3·2	40	197—196	+ 8·9	1·9	40	197—196	+ 8·9	1·9
	35+37—36—2·0=0				36+40—36A—0·6=0				37+40—38—1·8=0		
39	198—196	+6·9	0·8	41	199—198	−11·8	4·9	44	199—197	−15·9	5·5
40	197—196	+8·9	1·9	43	197—198	+ 1·8	1·8	45	200—197	+69·3	3·2
43	197—198	+1·8	1·8	44	199—197	−15·9	5·5	55	200—199	+86·1	4·9
	39+43—40—0·2=0				43+44—41—2·3=0				44+55—45+0·9=0		

Formation of Equations of Condition—*continued.*

Chains between Kimberley, Ottoshoop, and Kroonstad.—N—*continued.*

No.	Station.	Difference of Height.	1/W.	No.	Station.	Difference of Height.	1/W.	No.	Station.	Difference of Height.	1/W.
41	199—198	−11·8	4·9	51	200—202	−141·3	5·8	46	200—201	− 29·5	4·2
42	200—198	+72·4	4·5	52	199—202	−225·5	6·0	47	202—201	+104·6	3.8
55	200—199	+86·1	4·9	55	200—199	+ 86·1	4·9	51	200—202	−141·3	5·8
	41+55−42+1·9=0				52+55−51+1·9=0				47+51−46−7·2=0		
47	202—201	+104·6	3·8	49	202—203	+ 64·1	3·9	53	205—202	−183·6	5·8
48	203—201	+ 39·0	1·2	50	204—203	− 47·9	4·1	54	204—202	−108·3	6·0
49	202—203	+ 64·1	3·9	54	204—202	−108·3	6·0	56	205—204	− 75·4	4·6
	48+49−47−1·5=0				49+54−50+3·7=0				54+56 −53−0·1=0		
56	205—204	− 75·4	4·6	58	205—206	−110·1	3·8	60	208—205	− 12·3	2·4
57	204—206	− 28·9	2·4	59	207—206	− 8·5	0·4	61	207—205	+ 98·8	3·7
58	205—206	−110·1	3·8	61	207—205	+ 98·8	3·7	62	208—207	−111·5	3·2
	56+57−58+5·8=0				58+61−59−2·8=0				61+62−60−0·4=0		
62	208—207	−111·5	3·2	63	209—207	− 5·4	3·9	66	210—209	+ 80·3	3·2
63	209—207	− 5·4	3·9	64	210—207	+75·3	1·9	68	211—209	+220·4	3·7
65	209—208	+102·8	3·4	66	210—209	+80·3	3·2	69	211—210	+140·0	2·7
	62+65−63−3·3=0				63+66−64−0·4=0				66+69−68−0·1=0		
67	212—209	+ 90·5	2·3	70	212—211	−125·0	3·1	72	213—212	+349·4	4·3
68	211—209	+220·4	3·7	71	213—211	+225·6	3·7	73	214—212	+ 82·5	4·9
70	212—211	−125·0	3·1	72	213—212	+349·4	4·3	74	214—213	−266·5	5·1
	68+70−67+4·9=0				70+72−71−1·2=0				72+74−73+0·4=0		
74	214—213	−266·5	5·1	76	216—215	−181·6	6·2	79	218—214	+176·9	7·3
75	215—213	+ 66·2	2·3	77	215—214	+334·8	4·7	80	216—214	+155·3	4·3
77	215—214	+334·8	4·7	80	216—214	+155·3	4·3	82	218—216	+ 24·4	3·9
	74+77−75+2·1=0				76+77−80−2·1=0				80+82−79+2·8=0		
78	217—214	− 29·1	6·7	78	217—214	− 29·1	6·7	83	218—217	+206·2	4·6
79	218—214	+176·9	7·3	80	216—214	+155·3	4·3	84	219—217	+158·3	3·7
83	218—217	+206·2	4·6	81	217—216	−182·1	6·2	85	219—218	− 52·1	5·0
	78+83−79+0·2=0				80+81−78+2·3=0				83+85−84−4·2=0		
85	219—218	− 52·1	5·0	86	220—218	+71·5	5·8	88	222—218	+98·8	5·5
86	220—218	+ 71·5	5·8	87	221—218	+68·7	5·4	87	221—218	+68·7	5·4
95	219—220	−131·4	2·0	91	220—221	+15·2	2·7	89	221—222	−37·4	5·5
	86+95−85−7·8=0				87+91−86+12·4=0				88+89−87−7·3=0		
89	221—222	−37·4	5·5	91	220—221	+15·2	2·7	93	220—223	−67·5	5·4
90	223—222	+45·4	5·8	92	223—221	+78·4	3·2	94	224—223	−35·0	4·5
92	223—221	+78·4	3·2	93	220—223	−67·5	5·4	97	224—220	+29·3	5·2
	89+92−90−4·4=0				92+93−91−4·3=0				93+97−94−3·2=0		
96	225—220	−107·1	2·1	98	226—225	− 73·8	2·2	100	227—226	− 46·3	5·2
97	224—220	+ 29·3	5·2	99	224—225	+138·0	4·9	102	224—226	+212·6	3·8
99	224—225	+138·0	4·9	102	224—226	+212·6	3·8	103	227—224	−258·3	5·2
	96+99−97+1·6=0				98+102−99+0·8=0				102+103−100+0·6=0		
103	227—224	−258·3	5·2	100	227—226	− 46·3	5·2	101	92— 93	+166·3	Fixed
104	92—224	− 11·6	2·6	105	227— 92	−245·2	4·0	105	227— 92	−245·2	4·0
105	227— 92	−245·2	4·0	108	92—226	+201·3	5·5	107	93—227	+ 78·8	4·3
	104+105−103+1·5=0				105+108−100+2·4=0				105+107−0·1=0		
76	216—215	−181·6	6·2	02	228—215	+317·3	5·2	05	229—228	−178·1	4·5
02	228—215	+317·3	5·2	04	229—215	+138·2	4·7	06	230—228	−304·2	5·1
03	228—216	+499·8	6·2	05	229—228	−178·1	4·5	07	229—230	+127·0	4·8
	76+03−02+0·9=0				02+05−04+1·0=0				06+07−05+0·9=0		

FORMATION OF EQUATIONS OF CONDITION—*continued.*

No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.	No.	Stations.	Difference of Height.	$\frac{1}{W}$.
	CHAINS BETWEEN KIMBERLEY, OTTOSHOOP, AND KROONSTAD.—N—*continued.*										
07	229—230	+127·0	4·8	08	232—230	−614·1	4·6	011	232—231	− 58·7	5·9
09	231—230	−553·2	4·3	09	231—230	−553·2	4·3	012	233—231	−122·9	4·7
010	231—229	−685·4	5·6	011	232—231	− 58·7	5·9	014	233—232	− 56·0	6·9
	07+010—09—5·2=0				09+011—08+2·2=0				011+014—012+8·2=0		
013	234—232	+263·3	5·1	015	234—233	+322·3	7·0	016	235—233	+138·0	5·7
014	233—232	− 56·0	6·9	016	235—233	+138·0	5·7	017	176—233	+ 21·8	7·6
015	234—233	+322·3	7·0	018	235—234	−183·7	6·5	019	235—176	+122·5	Fixed
	014+015—013+3·0=0				015+018—016+0·6=0				017—016+9·3=0		
4	167—152	−342·0	2·9	60	208—205	— 12·3	2·4	018	235—234	—183·7	6·5
6	184—167	+138·3	4·2	65	209—208	+102·8	3·4	013	234—232	+263·3	5·1
14	186—184	+244·4	2·6	67	212—209	+ 90·5	2·3	08	232—230	—614·1	4·6
16	187—186	— 27·5	3·6	73	214—212	+ 82·5	4·9	06	230—228	—301·2	5·1
20	190—187	—332·9	3·2	78	217—214	— 29·1	6·7	03	228—216	+400·8	6·2
23	191—190	+130·2	4·1	84	219—217	+158·3	3·7	82	218—216	+ 24·4	3·9
31	194—191	+198·1	4·4	95	219—220	—131·4	2·0	88	222—218	+ 98·8	5·5
37	196—194	+101·4	3·2	96	225—220	—107·1	2·1	90	223—222	+ 45·4	5·8
39	198—196	+ 6·9	0·8	98	226—225	— 73·8	2·2	94	224—223	— 35·0	4·5
41	199—198	— 11·8	4·9	100	227—226	— 46·3	5·2	104	92—224	— 11·6	2·6
52	199—202	—225·5	6·0	107	93—227	+ 78·8	4·3	101	92— 93	+166·3	Fixed
53	205—202	—183·6	5·8								
	—4—6—14—16—20—23—31—37—39—41+52—53—60—65 —67—73—78—84+95—96—98—100—107—11·8=0								+018+013+08+06+03—82 —88—90—94—104—17·6=0		

FIGURE BETWEEN VERLOREN VLEI AND LIMPOPO.—O.

36	70—236	—1865·0	15·2	34	236—237	+1165·4	15·0	32	236—238	+1525·8	14·7
37	71—236	— 32·8	13·0	35	71—237	+1126·4	14·1	33	237—238	+ 373·2	14·5
38	70— 71	—1825·8	Fixed	37	71—236	— 32·8	13·0	34	236—237	+1165·4	15·0
	37—36+6·4=0				34+37—35+6·2=0				33+34—32+12·8=0		
30	238—239	—1023·9	18·3	27	239—240	+391·5	15·3	26	241—240	—346·3	17·2
31	237—239	— 628·5	16·8	28	237—240	—232·7	21·1	27	239—240	+391·5	15·3
33	237—238	+ 373·2	14·5	31	237—239	—628·5	16·8	29	239—241	+732·0	4·6
	30+33—31—22·2=0				27+31—28—4·3=0				26+29—27—5·8=0		
24	241—242	+415·3	19·9	15	242—243	+1138·1	9·7	9	243—247	—2030·9	12·0
25	240—242	+764·4	10·3	17	241—243	+1545·5	14·9	10	242—247	— 899·9	16·3
26	241—240	—346·3	17·2	24	241—242	+ 415·3	19·9	15	242—243	+1138·1	9·7
	25+26—24+2·8=0				15+24—17+7·9=0				9+15—10+7·1=0		
8	248—247	— 996·6	9·4	11	241—248	+ 511·6	20·9	6	248—249	+2173·9	16·6
9	243—247	—2030·9	12·0	12	243—248	—1031·1	10·8	7	247—249	+3165·7	9·4
12	243—248	—1031·1	10·8	17	241—243	+1545·5	14·9	8	248—247	— 996·6	9·4
	8+12—9+3·2=0				12+17—11+2·8=0				7+8—6—4·8=0		
2	248—250	+3640·4	18·6	3	247—250	+4636·9	19·1	1	251—250	+ 840·5	11·2
4	249—250	+1466·2	15·1	4	249—250	+1466·2	15·1	2	248—250	+3640·4	18·6
6	248—249	+2173·9	16·6	7	247—249	+3165·7	9·4	5	248—251	+2808·0	18·5
	4+6—2—0·3=0				4+7—3—5·0=0				1+5—2+8·1=0		
15	242—243	+1138·1	9·7	14	245—243	— 21·4	8·8	19	245—244	+ 690·2	9·2
16	244—243	— 710·1	2·5	15	242—243	+1138·1	9·7	20	242—244	+1847·9	8·7
20	242—244	+1847·9	8·7	23	242—245	+1154·7	5·0	23	242—245	+1154·7	5·0
	16+20—15—0·3=0				14+23—15—4·8=0				19+23—20—3·0=0		
18	246—244	—261·1	8·5	13	246—243	—971·0	1·9	21	245—246	+ 951·6	7·0
19	245—244	+690·2	9·2	16	244—243	—710·1	2·5	22	242—246	+2107·6	8·5
21	245—246	+951·6	7·0	18	246—244	—261·1	8·5	23	242—245	+1154·7	5·0
	18+21—19+0·3=0				16+18—13—0·2=0				21+23—22—1·3=0		

FORMATION OF EQUATIONS OF CONDITION—*continued*.

FIGURE BETWEEN PRETORIA AND JOHANNESBURG.—P.

No.	Station.	Difference of Height.	$\frac{1}{W}$	No.	Station.	Difference of Height.	$\frac{1}{W}$	No.	Station.	Difference of Height.	$\frac{1}{W}$
21	267—266	+436·9	1·9	19	96—265	+74·0	1·4	23	267— 96	+ 10·0	2·0
25	265—266	+353·9	1·4	23	267— 96	+10·0	2·0	24	267—266	+436·9	1·9
26	267—265	+ 81·1	2·4	26	267—265	+84·1	2·4	27	96—266	+426·8	2·2
	25+26—24+1·1=0				19+23—26—0·1=0				23+27—24—0·1=0		
18	96—264	+765·3	3·1	17	262—264	+358·1	3·0	17	262—264	+358·1	3·0
19	96—265	+ 74·0	1·4	20	265—262	+331·6	3·0	18	96—264	+765·3	3·1
21	265—264	+690·9	3·9	21	265—264	+690·9	3·9	22	96—262	+408·2	3·6
	19+21—18—0·4=0				17+20—21—1·2=0				17+22—18+1·0=0		
15	262—263	+478·6	2·8	13	262—260	+287·5	3·1	11	260—261	+179·5	1·8
16	264—263	+117·7	2·1	14	260—263	+189·5	2·2	12	262—261	+467·2	2·7
17	262—264	+358·1	3·0	15	262—263	+478·6	2·8	13	262—260	+287·5	3·1
	16+17—15—2·8=0				13+14—15—1·6=0				11+13—12—0·2=0		
9	260—259	+ 99·0	2·0	7	259—258	+ 96·2	2·5	5	257—258	+17·5	2·0
10	259—261	+ 80·1	2·0	8	260—258	+194·9	2·3	6	259—257	+79·9	2·2
11	260—261	+179·5	1·8	9	260—259	+ 99·0	2·0	7	259—258	+96·2	2·5
	9+10—11—0·4=0				7+9—8+0·3=0				5+6—7+1·2=0		
3	257—252	+164·5	2·6	1	252— 84	+ 48·0	1·8	1	252— 84	+ 48·0	1·8
4	258—252	+150·1	2·8	2	257— 84	+206·8	2·2	*a*	252—254	+167·7	2·5
5	257—258	+ 17·5	2·0	3	257—252	+164·5	2·6	*b*	84—254	+124·0	1·5
	4+5—3+3·1=0				1+3—2+0·7=0				1+*b*—*a*—0·7=0		
a	252—254	+167·7	2·5	1	252— 84	+ 48·0	1·8	18	96—264	+765·3	3·1
c	252—253	+149·9	2·3	*c*	252—253	+149·9	2·3	16	264—263	+117·7	2·1
e	253—254	+ 17·2	0·7	*d*	84—253	+106·1	1·8	14	260—263	+189·5	2·2
	c+*e*—*a*—0·6=0				1+*d*—*c*—0·8=0			8	260—258	+194·9	2·8
								4	258—252	+150·1	2·3
								1	252— 84	+ 48·0	1·8
									18+16—14+8+4+1—2·1=0		

PRETORIA QUADRILATERAL.—Q.

No.	Station.	Difference of Height.	$\frac{1}{W}$	No.	Station.	Difference of Height.	$\frac{1}{W}$	No.	Station.	Difference of Height.	$\frac{1}{W}$
a	254—255	+245·7	0·9	*b*	254—256	+82·5	0·9	*a*	254—255	+245·7	0·9
b	254—256	+ 82·5	0·9	*d*	253—256	+99·7	0·9	*e*	253—254	+ 17·4	Fixed
c	256—255	+161·8	0·8	*e*	253—254	+17·4	Fixed	*f*	253—255	+263·2	1·4
	b+*c*—*a*—1·4=0				*b*—*d*+0·2=0				*a*—*f*—0·1=0		

Table N.

Resulting Corrections to the Differences of Height.

EQUATION A.

31 = + 7·3
32 = − 3·1
33 = + 0·4
34 = + 5·0
35 = − 2·9
36 = + 0·3
37 = − 1·9
38 = − 1·3
39 = − 2·2
40 = − 3·1
41 = + 1·9
42 = + 1·1
43 = + 0·1
44 = + 2·5
45 = + 2·1
46 = − 0·4
47 = − 8·0
48 = + 10·5

EQUATION B.

1 = + 2·1
2 = + 2·2
3 = − 1·1
4 = + 0·8
5 = − 0·2

EQUATION C.

4 = − 0·9
7 = + 1·5
8 = − 0·1
9 = + 4·7
10 = + 5·3
11 = + 1·2
12 = + 0·1
13 = + 11·4
14 = + 3·4
15 = + 16·7
16 = + 5·7
17 = − 2·5
18 = + 6·6
19 = − 2·3
20 = − 3·6
21 = − 4·4
22 = − 1·4
23 = − 0·2
24 = − 1·3
25 = + 0·1
26 = − 1·4
27 = + 2·9
28 = + 2·3
29 = − 1·6

EQUATION D.

0 = − 4·6
1 = − 0·6
2 = − 1·1
3 = − 3·7
5 = − 0·6
6 = − 3·7

EQUATION E.

62 = − 3·0
63 = − 3·8
64 = + 4·4
65 = − 4·0
66 = − 0·6
67 = + 0·1
68 = + 3·3
69 = − 0·3
70 = − 2·3
71 = + 0·4
72 = + 0·6
73 = − 1·7
74 = + 0·7
75 = − 1·5
76 = + 1·3
77 = + 2·2
78 = − 2·1
79 = + 4·7

EQUATION F.

15 = + 5·6
16 = + 0·9
17 = − 1·5
18 = − 10·5
19 = + 3·6
20 = + 2·6
21 = + 3·1
22 = − 0·6
23 = + 1·4
24 = + 0·5
25 = + 5·1
26 = − 0·4
27 = − 0·4
28 = − 1·4
29 = − 0·5
30 = − 0·5
31 = + 0·9
32 = + 1·9
33 = − 9·7
34 = + 2·0
35 = + 4·2
36 = − 1·8
37 = + 5·2
38 = − 2·3
39 = − 2·8
40 = + 0·8
41 = + 0·5
42 = − 0·9

EQUATION G.

49 = − 3·4
50 = + 2·9
51 = − 10·1
52 = − 1·8
53 = + 3·8
54 = + 3·5
55 = − 3·9
56 = − 3·9
57 = + 1·8
58 = − 9·1
59 = − 1·8

Equation G (*cont.*).

60 = + 0·2
61 = + 1·8
2 = + 4·7
3 = − 3·5
4 = − 1·9
5 = + 0·8
6 = + 1·5
7 = − 4·9
8 = + 0·9
9 = − 3·1
10 = + 1·4
11 = + 0·4
12 = − 0·5
13 = + 1·5
14 = − 0·2

EQUATION H.

6 = + 3·2
7 = + 0·3
8 = − 1·2
9 = − 1·8
10 = + 0·4
11 = − 0·2
12 = − 0·5
13 = − 1·0
14 = − 1·7
15 = + 0·1
16 = − 1·3
17 = + 0·5
18 = − 2·4
19 = − 1·0
20 = 0·0

EQUATION I.

15 = − 0·5
16 = 0·0
17 = + 0·6
18 = + 0·6
19 = + 1·1
20 = − 0·4
21 = − 0·8
22 = + 0·9
23 = + 1·2
24 = − 0·8
25 = − 0·8
26 = + 0·4
27 = + 3·1

EQUATION J.

14A = − 1·0
14 = + 1·9
13 = + 3·2
12 = + 0·6
11 = + 3·2
10 = − 0·7
9 = − 1·5
8 = − 2·8
7 = + 4·1
6 = − 1·5

Equation J (*cont.*)

5 = + 0·1
4 = + 1·3
3 = − 2·0
2 = − 1·1
1 = + 1·6
0 = + 0·6

EQUATION K.

1 = + 1·3
2 = + 9·0
3 = − 2·9
4 = − 2·9
5 = − 0·6
6 = − 1·7
7 = + 0·1
8 = − 8·1
9 = + 0·5
10 = − 7·2
11 = − 7·5
12 = + 16·4
13 = − 5·0

EQUATION L.

1 = − 5·5
2 = − 1·0
4 = + 6·7
5 = + 0·7
6 = + 1·5
7 = + 1·0
8 = − 0·8
9 = − 0·1
10 = + 0·3
11 = 0·0
12 = + 0·3
13 = + 0·3
14 = − 0·2
15 = + 1·0
16 = + 1·7
17 = − 0·1
18 = − 1·4
19 = + 0·6
20 = + 2·2
21 = − 2·2
22 = + 0·8
23 = + 2·5
24 = + 0·5
25 = + 4·7
26 = + 2·4
27 = − 1·5

EQUATION M.

2 = + 4·6
3 = + 1·3
4 = − 1·2
5 = + 5·1
6 = + 0·5
7 = − 6·8
8 = − 5·1
9 = + 0·7

Equation M (*cont.*).

10 = − 2·1
11 = − 2·4
12 = − 3·8
13 = − 1·0
14 = − 1·9
15 = − 2·8
16 = − 1·1
17 = − 2·9
18 = − 2·1
19 = − 3·1
20 = + 2·2
21 = − 7·0
22 = − 1·5
23 = − 3·2
24 = + 4·7
25 = − 2·6
26 = − 0·1
27 = − 0·6
28 = − 3·7
29 = − 0·5
30 = − 1·3
31 = − 2·3
32 = + 1·8
33 = + 1·9
35 = + 3·2

EQUATION N.

2 = + 0·1
4 = − 4·1
5 = + 2·8
6 = + 0·5
7 = − 1·1
8 = − 1·6
9 = − 1·9
10 = + 1·1
11 = + 0·3
12 = + 0·1
13 = − 0·5
14 = + 0·4
15 = 0·0
16 = + 0·4
17 = + 0·3
18 = − 0·1
19 = 0·0
20 = − 0·3
21 = + 1·2
22 = − 0·1
23 = + 0·5
24 = − 1·0
25 = − 0·1
26 = + 2·6
27 = − 1·6
28 = + 1·1
29 = − 1·7
30 = − 1·9
31 = + 1·0
32 = + 2·4
33 = + 0·2
34 = + 0·2
35 = + 0·1
36 = − 0·6
36A = − 0·7
37 = + 1·3

TABLE N—*continued.*

Resulting Corrections to the Differences of Height.

Equation N (*cont.*).

38 = 0·0
39 = + 0·1
40 = + 0·5
41 = − 1·5
42 = + 0·3
43 = + 0·6
44 = + 0·2
45 = + 1·0
46 = − 3·7
47 = + 0·2
48 = + 1·1
49 = + 0·6
50 = + 3·0
51 = + 3·3
52 = + 1·5
53 = − 2·5
54 = − 1·3
55 = − 0·1
56 = − 1·1
57 = − 1·7
58 = + 3·0
59 = 0·0
60 = + 0·5
61 = − 0·2
62 = + 1·1
63 = − 0·8
64 = − 0·8
65 = + 1·9
66 = − 0·1
67 = + 2·0
68 = − 1·3
69 = − 1·1
70 = − 1·6
71 = − 1·1
72 = + 1·7

Equation N (*cont.*).

73 = − 0·2
74 = − 2·3
75 = + 1·3
76 = − 1·1
77 = + 1·5
78 = − 2·0
79 = − 0·6
80 = − 1·7
81 = − 2·6
82 = − 1·7
83 = + 1·2
84 = − 3·6
85 = − 0·6
86 = + 5·0
87 = − 5·2
88 = + 0·2
89 = + 1·9
90 = − 2·0
91 = − 2·2
92 = + 0·5
93 = + 1·6
94 = − 2·0
95 = + 2·2
96 = − 1·4
97 = − 0·4
98 = − 1·1
99 = − 0·6
100 = 0·0
102 = − 0·3
103 = − 0·3
104 = − 1·9
105 = + 0·1
107 = 0·0
108 = − 2·5
02 = + 1·3

Equation N (*cont.*).

03 = + 1·5
04 = + 3·7
05 = + 1·4
06 = + 0·9
07 = − 0·4
08 = + 1·4
09 = 0·0
010 = + 5·6
011 = − 0·8
012 = + 5·8
013 = + 2·3
014 = − 2·1
015 = + 1·4
016 = + 6·1
017 = − 3·2
018 = + 4·1

EQUATION O.

1 = − 2·7
2 = + 0·9
3 = + 0·3
4 = + 2·7
5 = − 4·5
6 = − 1·5
7 = + 2·6
8 = + 0·7
9 = − 0·1
10 = + 3·7
11 = + 3·4
12 = − 4·0
13 = − 0·5
14 = + 1·1

Equation O (*cont.*).

15 = − 3·3
16 = − 0·5
17 = + 4·6
18 = + 0·2
19 = + 0·1
20 = − 2.5
21 = − 0·4
22 = − 1·3
23 = + 0·4
24 = 0·0
25 = − 4·7
26 = + 1·9
27 = − 1·2
28 = − 10·5
29 = + 2·7
30 = + 14·5
31 = − 5·0
32 = + 8·9
33 = + 2·7
34 = − 6·6
35 = − 2·2
36 = + 4·6
37 = − 1·8

EQUATION P.

a = − 0·5
b = 0·0
c = − 0·1
d = + 0·5
e = + 0·2
1 = + 0·2
2 = + 1·6

Equation O (*cont.*).

3 = + 0·7
4 = − 0·9
5 = − 1·5
6 = + 0·4
7 = + 0·1
8 = + 0·7
9 = + 0·3
10 = − 0·1
11 = − 0·2
12 = + 0·4
13 = + 0·8
14 = − 0·3
15 = − 1·1
16 = + 1·2
17 = + 0·5
18 = + 0·6
19 = + 0·3
20 = + 1·4
21 = + 0·7
22 = − 0·9
23 = − 0·3
24 = + 0·3
25 = − 0·7
26 = − 0·1
27 = + 0·7

EQUATION Q.

a = − 0·4
b = + 0·3
c = + 0·7
d = + 0·5
f = − 0·5

Probable Error. 19. An analysis of the probable errors of height is given in the following Table:—

1	2	3	4	5	6	7	8	9	10
Figure.	Number of observed differences of height.	Number of conditions.	Number of triangles in figure.	Average length of side.	Probable error of a single observed difference of height.				Average probable error of an adjusted difference of height per mile.
					From errors of triangles.		From equations.		
				Miles.	Per average side.	Per mile.	Per mile.	Per average side.	
					Feet.	Feet.	Feet.	Feet.	Feet.
A	18	11	11	25·82	±3·04	±0·598	±0·620	±3·15	±0·39
B	5	3	3	9·18	1·04	0·343	0·432	1·31	0·27
C	24	13	13	31·20	5·07	0·907	0·838	4·68	0·57
D	6	4	4	30·30	2·24	0·407	0·583	3·21	0·34
E	18	10	10	28·55	2·26	0·466	0·525	2·55	0·35
F	28	17	17	23·05	2·65	0·551	0·589	2·83	0·37
G	26	14	14	45·08	2·97	0·418	0·548	3·68	0·37
H	15	9	8	29·24	0·73	0·136	0·185	1·00	0·12
I	13	8	8	15·67	0·97	0·246	0·260	1·03	0·16
J	16	9	9	37·26	1·61	0·264	0·306	1·87	0·20
K	13	8	7	41·63	4·37	0·679	0·952	6·11	0·59
L	26	16	15	31·15	1·50	0·269	0·357	1·09	0·22
M	33	19	18	25·19	2·68	0·534	0·554	2·78	0·36
N	122	68	66	12·40	1·42	0·404	0·473	1·67	0·32
O	37	21	21	37·91	±2·79	±0·453	±0·560	±3·45	±0·37
Weighted Means				27·9	±2·47	±0·47	±0·54	±2·85	±0·35

Column 1 gives the distinguishing letter for each set of equations.

„ 2 gives the number of observed differences of height in each set.

„ 3 gives the number of conditions.

„ 4 gives the number of triangles.

„ 5 gives the average length of a side in miles.

„ 6 gives the probable error of a single determination of a difference of height derived from the errors of closure in triangles, and computed by the formula $0{\cdot}6745\sqrt{\frac{\Sigma A^2}{3\,N}}$ where $\Sigma\,A^2$ is the sum of the squares of the triangular errors, and N is the number of triangles. The probable errors are for an average length of side in each figure.

„ 7 gives the probable errors per mile, obtained from the quantities in column 6 by the formula

$$\text{probable error per mile} = \frac{\text{probable error per average side}}{\sqrt{\text{number of miles in side}}}.$$

„ 8 gives the probable error per mile of a single determination, from the residuals after solution of equations, by the formula

$$0{\cdot}6745\ \sqrt{\frac{(pv^2)}{(n_c)}}$$

where (pv^2) is the sum of the weighted squares of the residuals, and n_c the number of conditions.

„ 9 gives the probable error of an average side by the formula:

probable error average side

$$= \text{probable error per mile} \times \sqrt{\text{number of miles in side}}.$$

Column 10 gives the average probable error (per mile) of an adjusted difference of height, computed by the formula

$$\epsilon' = \epsilon . \sqrt{\frac{n - n_c}{n}}$$

where ϵ is the probable error of observed difference of height (column 8)
n is the number of observations
n_c is the number of conditions.

Comparisons of results by vertical angles and levelling.

20. Assuming the average probable error of an adjusted difference of height to be ± 0·35 feet per mile, it is interesting to compare the theoretical probable errors with discordances between results from vertical angles and from actual levelling from Delagoa Bay. Taking Zwartkop, Natal, where the discordance is only 1·6 feet, as a datum, we have the following comparisons at other stations :—

Station.	Distance from Zwartkop.	Height.		L. — V.	Theoretical p.e. of V. Height.
		From V. Angles.	By Levelling.		
	Miles.	Feet.	Feet.	Feet.	Feet.
S. end Belfast base ..	280	6391·4	6399·9	+ 8·5	± 5·8
Muckleneuk	400	4739·8	4748·6	+ 8·8	± 7·0
Observatory Hill ..	460	5930·0	5936·1	+ 6·1	± 7·5
E. end Kroonstad base	670	4691·7	4684·4	— 7·3	± 9·1

The distances in the second column are through the chains in which the vertical heights were adjusted.

Heights of base lines.

21. The probable errors of the heights of the base lines are :—

Base Line.	Distance from Zwartkop.	Probable Error of Height.
	Miles.	Feet
Belfast	280	± 5·8
Ottoshoop	520	± 8·0
Wepener	830	± 10·1
Kroonstad	670	± 9·1
Houts River	440	± 7·4

COMPARISON OF THE BASE BARS WITH THE CAPE STANDARD.

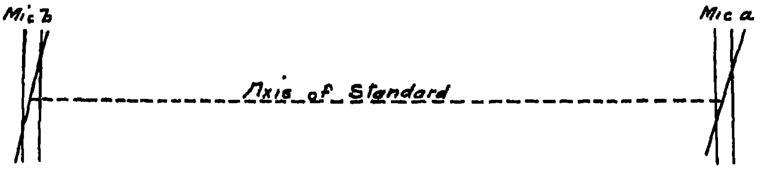
Previous comparison, 1888.

22. In 1888, November-December, the base bars were compared with the Cape Standard at the Royal Observatory. Full details of these comparisons are given in the "Report on the Geodetic Survey of South Africa," vol. I, chapter II. When the base measures for the present survey were completed it was decided to recompare the bars, in order to ascertain whether any displacement of the terminal lines has occurred since the 1888 comparisons. Accordingly the comparateur and the standard bar were brought up from the Cape. An iron shed was erected in the yard of the survey offices, the concrete piers and supporting walls for the rails were built, and the whole apparatus fitted as described in the report above referred to.

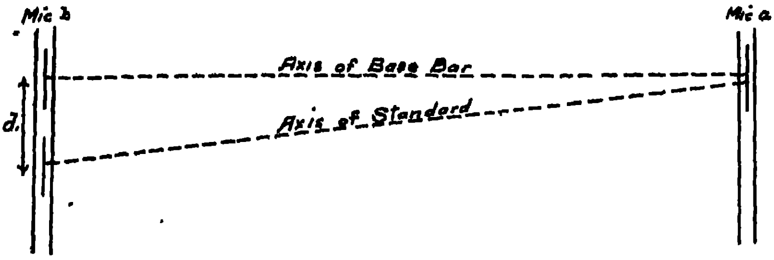
Defect in standard bar.

23. A defect, either common to all the base bars, or peculiar to the Standard, was discovered during the preliminary work. It was found im-

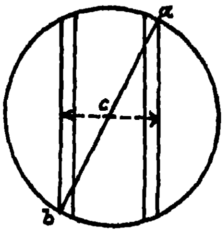
possible to place the wires of the micrometers so as to be parallel both to the terminal lines of the base bar and of the standard. That is to say, if the wires are set parallel to the lines on the base bar, and the standard is then brought under the microscopes, its lines are inclined thus :—



shewing that the inclination of the lines to the axis is different on the standard to what it is on the base bar. And this difference is the same for all the base bars. In consequence of this difference of inclination, when the bars are placed so that all the lines are parallel to each other, and are then brought under the microscopes, they lie thus :—



It is evident that if the distance d is greater than the field of view of the microscopes, it is impossible to compare the bars with all lines parallel. The field of view of the microscopes, in the direction of the wires, is 0·072 inch. The distance d was determined in two ways. The wires of the micrometers were set parallel to the lines on the base bar, and the standard then brought under the microscopes; the distance c (*see* figure), in the direction of the axis of the base bar, was measured with the micrometer; the wires were then set at right angles to ab, and the length ab measured. These measures gave the inclination $= \frac{1}{69}$, and this for a length of 10 feet gives $d = 1·75$ inches. Next, the bars were taken out of their boxes and supported, side by side, on one of the carriages of the comparateur. The wires of the micrometers were set parallel to the lines on the base bar, and the standard was moved until its lines were parallel to the wires. The distances between the extremities of the bars were then measured. As a check, the process was reversed, the wires being set on the standard and the base bar moved to parallelism. These measures gave $d = 1·9$ inches.



In the comparisons, the wires were always set parallel to the lines on the base bar, and the lines on the standard were bisected at their centres.

Summer and winter comparisons. 24. The comparison of the bars was commenced on Sept. 14 and continued to Oct. 26, 1905. The observers were Mr. Robinson and Mr. Cochrane. The conditions prevailing during these measures were very trying. The mean air temperature in the iron shed was frequently over 100 degrees Fahrenheit during the comparisons, and the temperature was seldom uniform throughout the room. The results of these comparisons were not considered satisfactory, and it was decided to re-compare the bars in the winter. The winter operations were commenced on May 22, and concluded on July 21, 1906. The observers were the Superintendent and Mr. Robinson.

Methods of comparison. 25. (A.) In the summer comparisons, the wires of the microscopes were set parallel to the lines of the bar under comparison with micrometer heads south, before beginning the measures of a bar. The comparison was then made as follows;—

I. (1.) The standard bar was brought under the microscopes, and both its thermometers read.

(2.) One observer took his stand at micrometer *a*, and made and recorded three pointings on the terminal division of the bar; the other observer simultaneously making three pointings with micrometer *b* on the other terminal division.

(3.) The observers exchanged ends, and made six pointings each, on the terminal line under his microscope.

(4.) The observers again exchanged ends, and made three pointings on the bar.

(5.) Thermometers were read.

II. The bar to be compared was brought under the microscopes, and the whole of the operations of process I. repeated.

III. The micrometer heads were turned through 180 degrees, and the wires, set parallel to the lines of the bar under comparison. Process II. was then repeated.

IV. Process I. was repeated.

These four processes constitute one complete comparison. Each observer recorded his own readings of micrometer heads and thermometers. The observers always faced east.

(B.) In the winter comparisons, the pointings and readings of thermometers were as described for the summer operations. The order, however, was changed, and the number of measures doubled. The readings were recorded by Mr. Cochrane. The order of comparison was as follows:—

Set.		Position of Observers.	Position of Micr. Heads.	Base Bar or Standard.
I.	1	Face East	North	Base Bar.
	2	" "	"	Standard.
II.	1	Face West	South	Standard.
	2	" "	"	Base Bar.
III.	1	Face West	Inwards	Base Bar.
	2	" "	"	Standard.
IV.	1	Face East	Outwards	Standard.
	2	" "	"	Base Bar.

These four sets constitute one complete comparison. In sets I. and III. the wires were set parallel to the lines on the base bar; in sets II. and IV. they were set on the standard, the normal inclination being estimated by the observers.

26. The thermometers used in the bars were:— **Thermometers.**

In the standard: Nos. 192886 and 116832.
In the base bars: Nos. 116839, 116833, and 116826.

These are all old thermometers. They were compared with the standard Tonnelot, 4514, at every 5 degrees Fahrenheit (approximately), in August and September, 1905, and in June and August, 1906. No sensible difference was found in the corrections determined on these dates. The adopted corrections are:—

Mean Reading.	Corrections to Mean of Standard Thermometers.	Corrections to Mean of Base Bar Thermometers.
°	°	°
32	− 0·48	− 0·48
35	0·50	0·52
40	0·48	0·51
45	0·42	0·50
50	0·38	0·52
55	0·40	0·51
60	0·40	0·48
65	0·39	0·43
70	0·44	0·40
75	0·45	0·36
80	0·47	0·28
85	0·47	0·30
90	0·45	0·28
95	0·41	0·28
100	− 0·41	− 0·25

Values of one revolution of micrometer screws.

27. The adopted mean values of one revolution of the micrometer screws are :—

For the measures in the Summer of 1905 :
Mic. a = 0·0853 mm. Mic. b = 0·0837 mm.
For the measures in the Winter of 1906 :
Mic. a = 0·0850 mm. Mic. b = 0·0837 mm.

These mean values depend upon measures of the standard millimetres A and B made by each observer during the observations.

Results.

28. The results, for both the summer and the winter comparisons, are given in the following pages :—

Column 1 gives the date of comparisons.

" 2 gives the true temperature (T), in degrees centigrade, of the standard bar.

" 3 gives the true temperature (t) of the base bar.

" 4 and 5 give the measured excess of the base bar above the standard, in terms of revolutions of the micrometer screws.

" 6 gives the excess expressed in millimetres.

" 7 gives the length of the standard at temperature T, computed by the formula

$$S_T = 3047{\cdot}4263\,(1 + 0{\cdot}000011820\,T + 0{\cdot}00000000833\,T^2)$$

" 8 gives the measured length of the base bar, that is, the sum of columns 6 and 7.

" 9 gives the length of the base bars, derived from the results of the comparisons in 1888, on the assumption that the true coefficients of expansion are the same for all the base bars. The lengths are computed by the formula

$$L_{t^\circ} = L_{23^\circ} + 0{\cdot}033105\,(t^\circ - 23^\circ) + 0{\cdot}00001923\,(t^\circ - 23^\circ)^2$$

where

L_{23° for bar A = 3048·1655 mm.
" " " B = 3048·1628
" " " C = 3048·1843
" " " D = 3048·1749
" " " E = 3048·1847

(G.S. Report, vol. I., p. [54])

" 10 gives the excess of the computed length of the base bar over its observed length, *i.e.*, the residual errors of observation C − O.

Below the tables are given the normals and the results of the solution for each bar. It is assumed that the observations may be represented by equations of the form

$$x + \theta \cdot y + \theta^2 \cdot z = A_t$$

and the values of the lengths of the bars and the coefficients of expansion, given above, are substituted in the equations as approximations to x, y, and z. θ is put $= t^\circ - 23^\circ$

COMPARISON OF BARS 1905 AND 1906.

Comparison of Bar A with Standard Bar in the Summer of 1905.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar A t.	$A_t - S_T$ In terms of micrometer Screws.		$A_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T.	Measured Length of Bar A at Temperature t.	1888 Length of Bar A at Temperature t.	Residuals.	
			a	*b*					Different Coefficients.	Same Coefficients.
1905	°C.	°C.	r	r	mm.	mm. 3047+	mm. 3047+	mm. 3047+	microns.	microns.
Oct. 20	22·94	25·17	+0·8144	−0·1584	+0·0187	1·2810	1·2447	1·2374	−5·58	−4·33
21	21·08	20·87	+0·4110	−1·2428	−0·0690	1·1648	1·0958	1·0951	+0·67	+1·55
21	21·52	21·52	+1·3245	−2·0874	−0·0618	1·1804	1·1186	1·1165	−0·71	+0·25
21	22·29	22·51	−0·5366	−0·1856	−0·0612	1·2079	1·1467	1·1493	+4·03	+5·09
23	23·80	12·23	−0·1631	−5·1602	−0·4458	1·2617	0·8159	0·8112	−2·18	−3·00
23	25·92	6·71	−3·3632	−4·9904	−0·7044	1·3375	0·6331	0·6313	+2·74	+0·15
23	27·17	4·23	−2·1598	−7·6485	−0·8244	1·3823	0·5579	0·5509	−1·22	−4·78
23	28·08	1·78	−3·6392	−7·4732	−0·9360	1·4150	0·4790	0·4717	−0·09	−4·72
24	22·55	17·65	−2·9673	+0·3245	−0·2259	1·2171	0·9912	0·9889	−0·79	−0·38
24	24·81	30·42	−2·5159	+3·9768	+0·1182	1·2978	1·4160	1·4122	−0·83	+0·41
24	25·70	34·14	−1·5637	+4·1059	+0·2103	1·3296	1·5399	1·5367	+1·21	+2·15
25	22·82	26·88	−1·8605	+2·9096	+0·0852	1·2089	1·2941	1·2942	+2·13	+3·42
25	23·14	30·83	−1·1699	+3·2558	+0·1728	1·2381	1·4109	1·4092	+1·25	+2·47
25	26·19	32·08	−1·5050	+3·0417	+0·1262	1·3472	1·4734	1·4677	−2·14	−1·01
26	23·78	24·50	−1·3067	+0·7850	−0·0457	1·2610	1·2153	1·2152	+1·53	+2·78

The resulting normals are

$$\begin{aligned} 15\,\Delta x - 33{\cdot}98\,\Delta y + 1556{\cdot}9\,\Delta z - 45{\cdot}0 &= 0 \\ -\,33{\cdot}98\,\Delta x + 1556{\cdot}9\,\Delta y - 18900{\cdot}6\,\Delta z + 238{\cdot}21 &= 0 \\ +\,1556{\cdot}9\,\Delta x - 18900{\cdot}6\,\Delta y + 439987{\cdot}4\,\Delta z - 8049{\cdot}74 &= 0 \end{aligned}$$

whence

	Microns.	Weight.	Probable Error Microns.
$\Delta x =$	+ 1·47	8·04	± 0·60
$\Delta y =$	+ 0·080	631	± 0·0674
$\Delta z =$	+ 0·01654	118690	± 0·0049

Probable error of a single comparison = ± 1·69 microns.

Equation of Bar A.

$$\begin{array}{l} \text{mm.} \\ 3048{\cdot}1670 + {\cdot}033185\,\theta + {\cdot}0000358\,\theta^2 \\ \quad \pm {\cdot}0006 \pm {\cdot}000067 \quad \pm {\cdot}0000049 \end{array}$$

where $\theta = t - 23^\circ$ Cent.

COMPARISON OF BAR B WITH STANDARD BAR IN THE SUMMER OF 1905.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar B *t*.	$B_t - S_T$ In terms of micrometer Screws.		$B_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T.	Measured Length of Bar B at Temperature *t*.	1888 Length of Bar B at Temperature *t*.	Residuals.	
			a	*b*					Different Coefficients.	Same Coefficients.
1905	°C.	°C.	*r*		mm.	mm. 3047 +	mm. 3047 +	mm. 3047 +	microns.	microns.
Sept. 14	13·73	7·06	+1·6727	−4·8474	−0·2631	0·9047	0·6416	0·6400	+3·56	+3·85
15	12·77	12·34	+3·0098	−3·6669	−0·0502	0·8710	0·8208	0·8121	−2·62	−3·46
15	16·94	21·13	+3·5000	−2·4483	+0·0937	1·0180	1·1117	1·1010	−3·61	−1·89
16	13·29	13·13	+2·4821	−3·0881	−0·0468	0·8898	0·8125	0·8379	+1·60	+0·63
18	9·24	9·16	+0·5818	−1·0138	−0·0850	0·7472	0·7122	0·7083	+1·66	+1·42
18	14·39	29·76	+2·1699	+8·4154	+0·4711	0·9280	1·3991	1·3875	−1·17	−4·06
19	12·08	12·72	+0·2201	−0·4035	−0·0150	0·8467	0·8317	0·8245	−1·06	−1·98
19	13·09	13·92	−0·6080	+0·4817	−0·0115	0·8822	0·8707	0·8638	−0·58	−1·65
19	16·29	17·53	−0·8745	+0·8213	−0·0059	0·9950	0·9891	0·9823	−0·04	−1·37
20	18·41	32·40	+3·0228	+1·8265	+0·4108	1·0700	1·4808	1·4757	+2·31	+3·20
22	15·96	10·25	+0·8767	−3·6745	−0·2329	0·9833	0·7504	0·7438	−0·86	−1·84
23	16·29	0·48	+0·6080	−7·3232	−0·5610	0·9950	0·4340	0·4270	−3·33	−0·67
23	18·03	5·07	+0·0925	−5·8188	−0·4791	1·0565	0·5771	0·5754	+2·75	+3·65
25	21·20	34·63	+2·5144	+2·0979	+0·3900	1·1691	1·5591	1·5504	−1·35	+0·33
25	23·25	32·84	+8·5665	−5·6819	+0·2551	1·2420	1·4971	1·4904	+0·70	+1·74
25	24·92	27·85	+7·2860	−7·0800	+0·0246	1·3017	1·3263	1·3238	+4·92	+4·56

The resulting normals are

$$
\begin{aligned}
16\,\Delta x - 87{\cdot}73\,\Delta y + 2259{\cdot}1\,\Delta z - 100{\cdot}6 &= 0\\
-\,87{\cdot}73\,\Delta x + 2259{\cdot}1\,\Delta y - 26358\,\Delta z + 383{\cdot}55 &= 0\\
+\,2259{\cdot}1\,\Delta x - 26358\,\Delta y + 567683\,\Delta z - 12292{\cdot}08 &= 0
\end{aligned}
$$

whence

	Microns.	Weight.	Probable Error Microns.
$\Delta x =$	+ 7·22	6·72	± 0·74
$\Delta y =$	+ 0·061	993	± 0·0609
$\Delta z =$	− 0·0043	138941	± 0·00516

Probable error of a single comparison = ± 1·92 microns.

Equation of Bar B.

$$
\begin{array}{l}
\text{mm.}\\
3048{\cdot}1700 + {\cdot}033166\,\theta + {\cdot}00001490\,\theta^2\\
\pm {\cdot}0007 \pm {\cdot}000061 \quad \pm {\cdot}0000052
\end{array}
$$

where $\theta = t - 23^\circ$ Cent.

COMPARISON OF BAR C WITH STANDARD BAR IN THE SUMMER OF 1905.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar C t.	$C_t - S_T$ In terms of micrometer Screws.		$C_t - S_T$ expressed in millimeters.	Length of Standard at Temperature T.	Measured length of Bar C at Temperature t.	1888 Length of Bar C at Temperature t.	Residuals.	
			a	b					Different Coefficients.	Same Coefficients.
1905	° C.	° C.	r	r	mm.	mm. 3047+	mm. 3047+	mm. 3047+	microns.	microns.
Oct. 16	17·78	11·20	−0·1168	−2·8393	−0·2477	1·0477	0·8000	0·7963	−2·55	− 1·33
16	18·77	8·13	−2·9405	−1·5998	−0·3847	1·0827	0·6980	0·6963	−1·88	+ 0·79
16	21·31	3·50	−4·4069	−3·0031	−0·6273	1·1730	0·5457	0·5461	−1·92	+ 3·37
16	23·84	1·99	−4·9294	−1·0036	−0·7556	1·2453	0·4897	0·4972	+4·44	+10·70
16	24·70	1·05	−5·7461	−4·0187	−0·8287	1·2939	0·4652	0·4669	−1·82	+ 5·05
17	18·29	12·76	−2·5123	−0·0373	−0·2174	1·0658	0·8484	0·8473	+0·70	+ 1·26
17	19·76	15·65	−2·8095	+0·7680	−0·1754	1·1179	0·9425	0·9420	+2·45	+ 1·94
17	20·59	17·05	−2·4920	+0·6508	−0·1581	1·1478	0·9892	0·9880	+2·28	+ 1·32
18	18·26	22·90	−1·8085	+3·2726	+0·1197	1·0647	1·1844	1·1810	+2·12	− 0·20
18	19·52	25·79	−1·5308	+3·6584	+0·1757	1·1094	1·2851	1·2768	−1·89	− 4·57
18	28·34	32·80	−0·6752	+3·9564	+0·2785	1·2458	1·5188	1·5106	+0·15	− 2·64
19	28·34	28·82	−2·2220	+3·9465	+0·1408	1·2458	1·3861	1·3776	−1·20	− 4·07
19	23·69	29·60	+2·2900	−0·4538	+0·1574	1·2578	1·4152	1·4036	−4·08	− 6·96
19	24·61	33·58	+3·0496	−0·0796	+0·2584	1·2906	1·5440	1·5367	+1·24	− 1·49
19	26·41	36·40	+2·3898	+0·9686	+0·2850	1·3551	1·6101	1·6314	+0·48	− 1·92
19	27·56	32·82	+2·0876	−0·6725	+0·1218	1·3963	1·5181	1·5112	+1·45	− 1·34

The resulting normals are

$$\begin{aligned}16\,\Delta x - 53{\cdot}96\,\Delta y + 2427{\cdot}3\,\Delta z - 61{\cdot}5 &= 0\\ -53{\cdot}96\,\Delta x + 2427{\cdot}3\,\Delta y - 27892\,\Delta z - 602{\cdot}46 &= 0\\ +2427{\cdot}3\,\Delta x - 27892\,\Delta y + 721426\,\Delta z - 1484{\cdot}50 &= 0\end{aligned}$$

whence

	Microns.	Weight.	Probable Error Microns.
$\Delta x =$	$+\,5{\cdot}55$	6·65	± 0·63
$\Delta y =$	$+\,0{\cdot}3254$	1146	± 0·048
$\Delta z =$	$-\,0{\cdot}00403$	180167	± 0·00393

Probable error of a single comparison = ± 1.63 microns.

Equation of Bar C.

$$\overset{\text{mm.}}{3048{\cdot}1899} + {\cdot}033430\theta + {\cdot}0000152\theta^2$$
$$\pm\,{\cdot}0006 \pm {\cdot}000048 \pm {\cdot}0000039$$

where $\theta = t - 23°$ Cent.

COMPARISON OF BAR D WITH STANDARD BAR IN THE SUMMER OF 1905.

1	2	3	4	5	6	7	8	9	10	11
Date	Temperature of Standard T.	Temperature of Bar D t.	$D_t—S_T$ In terms of micrometer Screws.		$D_t—S_T$ expressed in millimeters.	Length of Standard at Temperature T.	Measured length of Bar D at Temperature t.	1888 Length of Bar D at Temperature t.	Residuals.	
			a	b					Different Coefficients.	Same Coefficients.
1905	° C.	° C.	r	r	mm.	mm. 3047+	mm. 3047+	mm. 3047+	microns.	microns.
Oct. 9	20·83	20·73	+3·6804	—4·3203	—0·0517	1·1559	1·1042	1·0999	+0·80	+1·47
9	22·62	6·62	—3·8737	—2·8956	—0·5728	1·2196	0·6468	0·6378	—3·04	—3·50
9	26·11	2·51	—5·6934	—4·1804	—0·8856	1·3448	0·5087	0·5047	+3·04	+2·00
10	18·57	8·88	—2·5726	—1·6711	—0·3593	1·0757	0·7164	0·7097	—1·16	—1·36
10	20·66	3·08	—3·4301	—3·9148	—0·6202	1·1504	0·5302	0·5231	—0·23	—1·18
10	22·13	1·27	—2·7472	—5·8774	—0·7262	1·2022	0·4760	0·4646	—3·97	—5·20
10	23·13	0·82	—0·9836	—8·3051	—0·7790	1·2378	0·4588	0·4501	—1·12	—2·43
10	24·41	0·57	—2·8202	—7·1269	—0·8871	1·2835	0·4464	0·4420	+3·27	+1·92
11	14·24	10·26	+1·0816	—3·0339	—0·1617	0·9227	0·7610	0·7563	+0·62	+0·58
11	14·99	11·92	+1·0505	—2·6869	—0·1353	0·9491	0·8138	0·8105	+1·82	+1·91
11	15·89	13·32	—0·6148	—0·8215	—0·1213	0·9809	0·8596	0·8562	+1·61	+1·81
11	17·89	16·12	+0·6442	—1·8730	—0·1018	1·0516	0·9498	0·9481	+3·20	+3·64
12	14·97	19·70	+2·1084	—0·6411	+0·1263	0·9484	1·0747	1·0659	—3·79	—3·16
12	16·10	22·41	+2·1323	—0·0775	+0·1754	0·9883	1·1637	1·1554	—3·01	—2·30
12	18·96	27·00	+2·1773	+0·4686	+0·2245	1·0895	1·3140	1·3076	—0·27	+0·47
12	19·65	27·34	—5·2944	+7·9081	+0·2102	1·1140	1·3242	1·3189	+0·90	+1·65
13	15·81	30·25	—2·1844	+7·4610	+0·4424	0·9781	1·4205	1·4159	+2·39	+3·09
13	16·38	31·67	+1·5589	+4·0782	+0·4785	0·9982	1·4717	1·4634	—0·85	—0·21
13	18·48	34·88	+1·1787	+4·6675	+0·4912	1·0707	1·5619	1·5541	+0·63	+1·16
13	19·55	35·33	—0·4408	+6·2479	+0·4853	1·1104	1·5957	1·5860	—0·88	—0·42

The resulting normals are

$$\begin{aligned}
20\ \Delta x &- 135{\cdot}87\ \Delta y + 3639{\cdot}6\ \Delta z - 127{\cdot}9 = 0\\
-\ 135{\cdot}87\ \Delta x &+ 3639{\cdot}6\ \Delta y - 56386\ \Delta z + 827{\cdot}3 = 0\\
+\ 3639{\cdot}6\ \Delta x &- 56386\ \Delta y + 1265624\ \Delta z - 25374 = 0
\end{aligned}$$

whence

	Microns.	Weight.	Probable Error Microns.
Δx	$=+\ 5{\cdot}37$	8·92	$\pm\ 0{\cdot}521$
Δy	$=+\ 0{\cdot}1438$	1055	$\pm\ 0{\cdot}0477$
Δz	$=+\ 0{\cdot}01103$	234302	$\pm\ 0{\cdot}00321$

Probable error of a single comparison $= \pm\ 1{\cdot}55$ microns.

Equation of Bar D.

$$\begin{aligned}
&\text{mm.}\\
&3048{\cdot}1803 + {\cdot}033249\,\theta + {\cdot}0000303\,\theta^2\\
&\pm {\cdot}0005 \pm {\cdot}000048 \quad \pm {\cdot}0000032
\end{aligned}$$

where $\theta = t - 23°$ Cent.

Comparison of Bar E with Standard Bar in the Summer of 1905.

1	2	3	4	5	6	7	8	9	10	11
Date	Temperature of Standard T.	Temperature of Bar E t.	E_t—S_T In terms of micrometer Screws.		E_t—S_T expressed in millimetres.	Length of Standard at Temperature T.	Measured length of Bar E at Temperature t.	1888 length of Bar E at Temperature t.	Residuals.	
			a	b					Different Coefficients.	Same Coefficients.
						mm.	mm.	mm.		
1905	° C.	° C.	r	r	mm.	3047+	3047+	3047+	microns	microns
Sept. 27	19·52	20·67	−0·2956	+0·3484	+0·0039	1·1094	1·1133	1·1078	+0·70	+1·38
28	17·57	17·57	−0·8856	+0·5183	−0·0322	1·0402	1·0080	1·0055	+3·66	+4·07
28	18·22	18·46	−1·0188	+0·8151	−0·0187	1·0633	1·0446	1·0348	−3·68	−3·16
29	17·84	12·03	−2·9432	+0·3992	−0·2177	1·0498	0·8321	0·8237	−1·79	−2·03
29	19·07	14·77	−2·4639	+0·4195	−0·1751	1·0934	0·9183	0·9134	+1·40	+1·50
30	16·18	15·76	−0·7651	+0·2734	−0·0423	0·9911	0·9488	0·9462	+3·62	+3·84
30	16·98	16·90	−1·7951	+1·4604	−0·0309	1·0194	0·9885	0·9833	+0·98	+1·32
Oct. 3	14·03	−0·19	−4·9020	−0·7671	−0·4823	0·9153	0·4330	0·4272	+4·55	+1·79
3	15·07	1·99	+0·7052	−5·9883	−0·4410	0·9519	0·5109	0·4976	−3·89	−6·10
4	17·52	13·03	+2·1446	−4·2739	−0·1749	1·0385	0·8636	0·8565	−0·62	−0·74
4	18·06	9·59	+1·9978	−5·6520	−0·3027	1·0576	0·7549	0·7442	−3·64	−4·28
4	20·47	7·05	+0·5069	−6·1739	−0·4735	1·1431	0·6696	0·6616	−0·82	−1·42
5	18·51	22·50	+3·7048	−2·5654	+0·1013	1·0735	1·1748	1·1681	−0·27	+0·44
5	19·22	27·78	+3·7452	−0·8293	+0·2501	1·0987	1·3488	1·3436	+2·10	+2·98
5	20·07	29·60	+3·6933	−0·3873	+0·2826	1·1289	1·4115	1·4040	+0·38	+1·14
5	22·84	33·15	+4·7669	−1·2109	+0·3053	1·2275	1·5328	1·5227	−1·01	−0·44
5	23·75	35·04	+4·7838	−0·8289	+0·3344	1·2599	1·5943	1·5862	+1·77	+2·20
6	21·64	36.18	+4·7018	+0·5734	+0·4491	1·1847	1·6338	1·6227	−0·74	−0·41
6	23·46	34·09	+4·4591	−0·7838	+0·3148	1·2496	1·5644	1·5542	−0·73	−0·22
6	25·42	28·37	+3.6444	−3·0683	+0·0586	1·3196	1·3782	1·3630	−2·65	−1·88

The resulting normals are

$$20 \quad \Delta x - 65{\cdot}69 \ \Delta y + 2484{\cdot}7 \ \Delta z - 152{\cdot}9 = 0$$
$$- 65{\cdot}69 \ \Delta x + 2484{\cdot}7 \ \Delta y - 24983 \ \Delta z + 424{\cdot}96 = 0$$
$$+ 2484{\cdot}7 \ \Delta x - 24983 \ \Delta y + 695222 \ \Delta z - 21756{\cdot}03 = 0$$

whence

	Microns.	Weight.	Probable Error Microns.
$\Delta x =$	$+ 6{\cdot}49$	10·8	$\pm 0{\cdot}523$
$\Delta y =$	$+ 0{\cdot}1284$	1537	$\pm 0{\cdot}0439$
$\Delta z =$	$+ 0{\cdot}01273$	261816	$\pm 0{\cdot}00336$

Probable error of a single comparison = ± 1·72 microns.

Equation of Bar E.

$$\text{mm.}\quad 3048{\cdot}1912 + {\cdot}033233\,\theta + {\cdot}0000319\,\theta^2$$
$$\pm{\cdot}0005 \quad \pm{\cdot}000044 \quad \pm{\cdot}0000034$$

where $\theta = t - 23°$ Cent.

Comparison of Bar A with Standard Bar in the Winter of 1906.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar A t.	$A_t - S_T$ In terms of micrometer Screws.		$A_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T.	Measured length of Bar A at Temperature t.	1888 length of Bar A at Temperature t.	Residuals.	
			a	*b*					Different Coefficients.	Same Coefficients.
						mm. 3047 +	mm. 3047 +	mm. 3047 +		
1906	° C.	° C.	*r*	*r*	mm.				microns	microns
May 22	10·41	10·44	+0·2121	−0·6694	−0·0379	0·7882	0·7503	0·7528	+0·22	+0·87
23	12·81	34·33	+6·9404	+0·9398	+0·6686	0·8726	1·5112	1·5432	+1·84	−0·21
23	15·12	36·91	+3·9371	+4·1070	+0·6785	0·9536	1·6320	1·6307	−1·27	−3·79
26	11·06	10·94	+0·8868	−1·4212	−0·0436	0·8108	0·7672	0·7690	−0·43	+0·19
28	11·18	1·63	−0·1900	−3·6649	−0·3185	0·8149	0·4665	0·4669	−2·81	−1·77
28	12·87	−0·01	+0·0530	−5·6195	−0·4659	0·8745	0·4087	0·4130	+0·90	+1·98
29	13·49	6·73	+0·3808	−3·5993	−0·2689	0·8963	0·6275	0·6322	+2·04	+2·89
30	12·24	11·16	+2·1185	−3·0591	−0·0759	0·8524	0·7765	0·7761	−2·31	−1·70
June 2	8·56	20·67	+0·6618	+3·6953	+0·3656	0·7235	1·0888	1·0886	−1·51	−1·71
5	10·93	27·27	+5·2993	+0·5863	+0·4995	0·8065	1·3060	1·3071	+0·37	−0·64
6	8·58	8·16	+1·2096	−1·7228	−0·0414	0·7240	0·6826	0·6882	+3·11	+3·89

The resulting normals are

$$\begin{aligned} 11\ \Delta x &- 84{\cdot}47\ \Delta y + 2253{\cdot}3\ \Delta z + 20{\cdot}8 = 0 \\ -\ 84{\cdot}47\ \Delta x &+ 2253{\cdot}3\ \Delta y - 30538\ \Delta z - 307{\cdot}7 = 0 \\ +\ 2253{\cdot}3\ \Delta x &- 30538\ \Delta y + 725377\ \Delta z + 5558{\cdot}4 = 0 \end{aligned}$$

whence

	Microns.	Weight.	Probable Error Microns.
$\Delta x =$	$-\ 1{\cdot}10$	3·9	$\pm\ 0{\cdot}71$
$\Delta y =$	$+\ 0{\cdot}088$	941	$\pm\ 0{\cdot}014$
$\Delta z =$	$-\ 0{\cdot}00050$	154634	$\pm\ 0{\cdot}00356$

Probable error of a single comparison = ± 1·40 microns.

Equation of Bar A.

$$\begin{aligned} &\text{mm.} \\ &3048{\cdot}1644 + {\cdot}033193\,\theta + {\cdot}0000187\,\theta^2 \\ &\quad \pm{\cdot}0007 \ \pm{\cdot}000014 \ \ \pm{\cdot}0000036 \end{aligned}$$

where $\theta = t - 23°$ Cent.

COMPARISON OF BAR B WITH STANDARD BAR IN THE WINTER OF 1906.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar B t.	$B_t - S_T$ In terms of micrometer Screws.		$B_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T	Measured Length of Bar B at Temperature t.	1888 Length of Bar B at Temperature t.	Residuals.	
			a.	b.					Different Coefficients.	Same Coefficients.
1906	° C.	° C.	r.	r.	mm.	mm. 3047 +	mm. 3047 +	mm. 3047 +	microns.	microns.
July 18	10·41	10·61	+0·7542	−1·1654	−0·0335	0·7883	0·7548	0·7557	+0·48	−0·84
18	10·47	10·67	+0·7480	−1·1700	−0·0343	0·7903	0·7560	0·7574	+2·77	+1·46
14	7·74	7·39	−1·8278	+1·3867	−0·0393	0·6948	0·6555	0·6509	−3·23	−4·69
14	7·74	7·40	−1·8860	+1·3811	−0·0405	0·6949	0·6541	0·6510	−2·03	−3·49
16	5·71	−0·34	−2·0897	−0·5171	−0·2209	0·6238	0·4029	0·4008	−1·31	−2·77
16	7·62	−0·89	−2·3028	−1·3510	−0·3088	0·6907	0·3819	0·3830	+1·82	+0·38
16	7·68	−0·87	−2·3012	−1·4079	−0·3134	0·6926	0·3791	0·3837	+5·33	+3·88
17	6·02	−1·21	−1·9376	−1·0932	−0·2562	0·6346	0·3784	0·3728	−4·98	−6·36
18	7·09	36·97	+5·4870	+5·8460	+0·9557	0·6721	1·6277	1·6291	−2·48	+0·48
18	7·51	36·04	+4·7908	+5·9780	+0·9076	0·6865	1·5941	1·5977	+0·16	+2·88
19	5·91	36·68	+4·6167	+7·0186	+0·9799	0·6309	1·6108	1·6177	+3·15	+6·01
19	8·59	36·78	+4·4722	+6·1756	+0·8970	0·7242	1·6218	1·6227	−2·32	+0·60
20	5·88	8·39	−0·0691	+0·9080	+0·0697	0·6128	0·6820	0·6882	+2·58	+1·16
20	6·06	28·24	+2·2690	+6·0246	+0·6972	0·6359	1·3330	1·3367	+2·66	+3·59
20	6·49	28·06	+2·2696	+5·7801	+0·6768	0·6510	1·3277	1·3309	+2·20	+3·09
20	8·68	19·14	−0·6411	+4·3885	+0·3128	0·7260	1·0389	1·0352	−2·98	−3·53
21	8·34	22·18	+0·5198	+4·5147	+0·4221	0·7156	1·1377	1·1356	−1·84	−1·97

The resulting normals are

$$\begin{array}{rrrr}
17\ \Delta x - & 105{\cdot}81\ \Delta y + & 4087{\cdot}10\ \Delta z + & 5{\cdot}90 = 0 \\
-\ 105{\cdot}81\ \Delta x + & 4087{\cdot}1\ \ \Delta y - & 58330\ \ \Delta z + & 378{\cdot}4\ = 0 \\
+\ 4087{\cdot}10\ \Delta x - & 58330\ \ \Delta y + & 1640792\ \ \Delta z - & 273\ \ = 0
\end{array}$$

whence

	Microns.	Weight.	Probable Error. Microns.
Δx	$= +\ 0{\cdot}11$	5·6	± 0·87
Δy	$= -\ 0{\cdot}1853$	1780	± 0·0488
Δz	$= -\ 0{\cdot}00669$	342648	± 0·00352

Probable error of a single comparison = ± 2·06 microns.

Equation of Bar B.

$$\begin{array}{l}
\text{mm.} \\
3048{\cdot}1629 + {\cdot}032920\,\theta + {\cdot}0000125\,\theta^2 \\
\quad \pm {\cdot}0009 \pm {\cdot}000049 \quad \pm {\cdot}0000035
\end{array}$$

where $\theta = t - 23°$ Cent.

COMPARISON OF BAR C WITH STANDARD BAR IN THE WINTER OF 1906.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar C *t*.	$C_t - S_T$ In terms of micrometer Screws.		$C_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T.	Measured Length of Bar C at Temperature *t*.	1888 Length of Bar C at Temperature *t*.	Residuals.	
			a.	*b*.					Different Coefficients.	Same Coefficients.
						mm.	mm.	mm.		
1906	° C.	° C.	r.	r.	mm.	3047 +	3047 +	3047 +	microns.	microns.
July 5	6·68	6·82	−2·1351	+2·1204	−0·0010	0·6577	0·6537	0·6539	+2·60	+2·39
5	6·70	6·83	−2·1090	+2·0785	−0·0058	0·6582	0·6525	0·6540	+3·90	+3·69
5	9·97	36·41	+3·8947	+6·3769	+0·8647	0·7729	1·6377	1·6315	−1·68	−1·55
5	10·04	36·43	+3·8868	+6·3268	+0·8599	0·7752	1·6348	1·6322	−1·18	−1·05
6	6·22	17·34	+0·4580	+3·8558	+0·3616	0·6414	1·0031	0·9976	−2·42	−3·00
6	6·22	17·31	+0·4374	+3·8273	+0·3575	0·6117	0·9992	0·9965	+0·37	−0·20
6	9·91	−1·47	−2·7084	−1·8503	−0·3851	0·7701	0·3853	0·3858	+1·56	+2·03
6	9·95	−1·50	−2·7195	−1·8481	−0·3859	0·7723	0·3864	0·3848	+0·56	−0·07
7	8·92	−0·49	−2·4051	−1·3296	−0·3157	0·7359	0·4202	0·4171	−1·85	−1·17
9	8·26	8·66	−1·9464	+2·0153	+0·0034	0·7129	0·7163	0·7137	0·00	−0·31
9	8·29	8·68	−1·9680	+2·0080	+0·0008	0·7138	0·7146	0·7143	+2·20	+1·89
9	11·01	10·69	−2·8397	+2·0297	−0·0290	0·8091	0·7801	0·7799	+2·58	+2·18
10	7·66	−0·02	−2·9841	+0·0106	−0·2528	0·6905	0·4377	0·4323	−1·06	−3·73
10	7·66	−0·04	−3·0157	−0·0163	−0·2576	0·6918	0·4342	0·4319	−0·96	−0·63
11	8·92	36·60	+3·5678	+7·0901	+0·8948	0·7362	1·6310	1·6381	+8·18	+8·63
11	8·91	36·58	+3·5819	+7·1040	+0·8990	0·7356	1·6346	1·6374	+1·29	+1·13
12	7·58	37·06	+4·9397	+6·5604	+0·9690	0·6873	1·6563	1·6536	−1·51	−1·32
12	7·58	37·04	+4·9291	+6·5396	+0·9664	0·6891	1·6555	1·6529	−1·31	−1·12
12	10·67	27·42	+3·2205	+3·2811	+0·5441	0·7971	1·3413	1·3312	−7·11	−7·86

The resulting normals are

$$\begin{array}{rlrlrlrl} & 19\,\Delta x & - & 116{\cdot}63\,\Delta y & + & 5105{\cdot}5\,\Delta z & - & 35{\cdot}80 = 0 \\ - & 116{\cdot}63\,\Delta x & + & 5105{\cdot}5\,\Delta y & - & 67849\,\Delta z & + & 210{\cdot}2 = 0 \\ + & 5105{\cdot}5\,\Delta x & - & 67849\,\Delta y & + & 2044017\,\Delta z & - & 7902 = 0 \end{array}$$

whence

	Microns.	Weight.	Probable Error. Microns.
Δx	$= + 2{\cdot}97$	5·3	$\pm 1{\cdot}12$
Δy	$= - 0{\cdot}0473$	2406	$\pm 0{\cdot}0524$
Δz	$= - 0{\cdot}00512$	368438	$\pm 0{\cdot}00423$

Probable error of a single comparison = ± 2·57 microns.

Equation of Bar C.

$$\begin{array}{c} \text{mm.} \\ 3048{\cdot}1873 + {\cdot}0330580\theta + {\cdot}0000141\theta^2 \\ \pm {\cdot}0011 \pm {\cdot}000052 \pm {\cdot}0000042 \end{array}$$

where $\theta = t - 23°$ Cent.

COMPARISON OF BAR D WITH STANDARD BAR IN THE WINTER OF 1906.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar D t.	$D_t - S_T$ In terms of micrometer Screws.		$D_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T.	Measured length of Bar D at Temperature t.	1888 Length of Bar B at Temperature t.	Residuals.	
			a	*b*					Different Coefficients.	Same Coefficients.
1906	° C.	° C.	*r*	*r*	mm.	mm 3047 +	mm. 3047 +	mm. 3047 +	microns.	microns.
June 26	6·61	7·19	−0·9793	+0·9539	−0·0035	0·6551	0·6517	0·6562	+2·22	+4·02
26	6·78	7·30	−0·5020	+0·4369	−0·0061	0·6612	0·6551	0·6599	+2·50	+4·33
27	6·59	−0·17	−3·6056	+0·8173	−0·2381	0·6545	0·4164	0·4182	+1·22	+0·77
27	7·03	0·40	−3·2789	+0·5581	−0·2320	0·6699	0·4380	0·4365	−2·25	−2·47
27	9·10	4·05	−0·8294	−1·3889	−0·1867	0·7421	0·5554	0·5543	−2·80	−1·78
28	7·10	20·84	−2·4756	+7·6624	+0·4309	0·6723	1·1032	1·1034	−2·32	−0·02
29	6·22	22·70	+2·0556	+4·1968	+0·5217	0·6419	1·1636	1·1649	−0·96	+1·04
29	9·26	36·36	+6·7613	+3·5399	+0·8710	0·7479	1·6189	1·6206	+3·50	+0·56
30	7·22	18·59	+5·2276	−1·1713	+0·3468	0·6765	1·0229	1·0292	+3·56	+6·11
July 2	7·63	35·20	+4·8296	+5·8169	+0·8974	0·6911	1·5884	1·5817	−5·40	−7·72
2	9·90	37·17	+3·9450	+6·5117	+0·8804	0·7703	1·6507	1·6479	−0·63	−4·01
3	6·50	35·70	+3·6689	+7·5573	+0·9444	0·6516	1·5960	1·5986	+4·12	+1·53
3	12·26	28·76	+3·2672	+2·8341	+0·5149	0·8531	1·3680	1·3661	−2·82	−2·43

The resulting normals are

$$
\begin{aligned}
13\ \Delta x - 44{\cdot}91\ \Delta y + 2650\ \Delta z + 9{\cdot}20 &= 0\\
-44{\cdot}91\ \Delta x + 2650\ \Delta y - 29420\ \Delta z - 238{\cdot}7 &= 0\\
+2650\ \Delta x - 29420\ \Delta y + 923128\ \Delta z + 1337 &= 0
\end{aligned}
$$

whence

	Microns.	Weight.	Probable Error Microns.
Δx =	− 2·21	4·5	± 1·05
Δy =	+ 0·165	1422	± 0·059
Δz =	+ 0·01016	218329	± 0·00477

Probable error of a single comparison = ± 2·23 microns.

Equation of Bar D.

$$
\begin{array}{l}
\text{mm.}\\
3048{\cdot}1727 + {\cdot}033270\,\theta + {\cdot}0000294\,\theta^2\\
\quad\pm {\cdot}0011 \pm {\cdot}000059 \quad \pm {\cdot}0000048
\end{array}
$$

where $\theta = t - 23°$ Cent.

COMPARISON OF BAR E WITH STANDARD BAR IN THE WINTER OF 1906.

1	2	3	4	5	6	7	8	9	10	11
Date.	Temperature of Standard T.	Temperature of Bar E t.	$E_t - S_T$ In terms of micrometer Screws.		$E_t - S_T$ expressed in millimetres.	Length of Standard at Temperature T.	Measured length of Bar E at Temperature t.	1888 Length of Bar E at Temperature t.	Residuals.	
			a	b					Different Coefficients.	Same Coefficients.
						mm.	mm.	mm.		
1906	°C	°C	r	r	mm.	3047+	3047+	3047+	microns.	microns.
June 7	10·44	10·59	+1·7252	−1·9274	−0·0147	0·7894	0·7748	0·7767	0·00	−0·70
7	12·82	12·95	+1·5562	−1·8358	−0·0214	0·8729	0·8515	0·8538	+0·64	−0·23
8	11·31	36·19	+5·3999	+4·1557	+0·8068	0·8198	1·6266	1·6248	−5·76	−5·19
9	7·55	17·86	−0·5124	+4·4056	+0·8252	0·6881	1·0133	1·0149	+0·19	−0·87
11	10·92	0·47	−1·3474	−2·9538	−0·3617	0·8061	0·4443	0·4485	+0·19	+0·94
12	7·81	−0·11	+0·6046	−3·9168	−0·2713	0·6978	0·4260	0·4298	−0·38	+0·49
13	11·42	36·15	+7·1085	+2·2724	+0·7944	0·8236	1·6180	1·6234	+1·45	+2·01
14	10·07	34·62	+8·6140	+0·6577	+0·7872	0·7759	1·5629	1·5719	+5·47	+5·75
14	11·72	36·68	+8·3310	+1·0062	+0.7998	0·8341	1·6338	1·6393	+1·41	+2·06
15	8·88	25·29	+6·4367	−0·2855	+0·5274	0·7829	1·2603	1·2606	−1·39	−2·23
15	10·42	31·18	+7·7302	+0·1235	+0·6674	0·7887	1·4561	1·4564	−2·43	−2·67
16	7·95	9·97	+2·1897	−1·5526	+0·0561	0·7024	0·7585	0·7564	−4·09	−4·72
18	9·18	4·38	+0·2565	−2·3304	−0·1733	0·7450	0·5718	0·5749	+0·10	+0·16
19	8·80	0·84	−0·7608	−2·7094	−0·2915	0·7318	0·4404	0·4443	−0·15	+0·64
19	9·08	0·94	−0·8833	−2·4699	−0·2818	0·7413	0·4595	0·4638	+0·42	+1·09
19	11·40	12·39	+2·1540	−2·1181	+0·0065	0·8228	0·8292	0·8352	+4·29	+3·46

The resulting normals are

$$\begin{aligned} 16\,\Delta x - 98{\cdot}16\,\Delta y + 3692{\cdot}1\,\Delta z + 47{\cdot}8 &= 0 \\ -98{\cdot}16\,\Delta x + 3692{\cdot}1\,\Delta y - 49843\,\Delta z - 284{\cdot}43 &= 0 \\ +3692{\cdot}1\,\Delta x - 49843\,\Delta y + 1357129\,\Delta z + 13097 &= 0 \end{aligned}$$

whence

	Microns.	Weight.	Probable Error Microns.
Δx	$= -1{\cdot}58$	5·2	± 0·87
Δy	$= -0{\cdot}074$	1626	± 0·049
Δz	$= -0{\cdot}00807$	265868	± 0·00384

Probable error of a single comparison = ± 1·98 microns

Equation of Bar E.

$$\begin{array}{l} \text{mm.} \\ 3048{\cdot}1831 + {\cdot}033031\,\theta + {\cdot}0000112\,\theta^2 \\ \pm {\cdot}0009 \quad \pm {\cdot}000049 \quad \pm {\cdot}0000038 \end{array}$$

where $\theta = t - 23°$ Cent.

29. If it is assumed that the coefficients of expansion are the same for all the base bars, we get for the lengths of the bars :— Lengths of bars.

From the comparisons in the summer of 1905 :

$$\left.\begin{array}{r} \text{mm} \\ A=3048{\cdot}1681 \\ \pm{\cdot}0006 \\ \\ B=3048{\cdot}1689 \\ \pm{\cdot}0006 \\ \\ C=3048{\cdot}1875 \\ \pm{\cdot}0006 \\ \\ D=3048{\cdot}1810 \\ \pm{\cdot}0006 \\ \\ E=3048{\cdot}1919 \\ \pm{\cdot}0005 \end{array}\right\} \begin{array}{l} +0{\cdot}033268\theta+0{\cdot}0000269\theta^2 \\ \pm\ {\cdot}000028\ \pm\ {\cdot}0000021 \end{array}$$

Probable error of a single comparison :
microns
±2·08

From the winter comparisons of 1906 :

$$\left.\begin{array}{r} A=3048{\cdot}1639 \\ \pm{\cdot}0007 \\ \\ B=3048{\cdot}1629 \\ \pm{\cdot}0007 \\ \\ C=3048{\cdot}1867 \\ \pm{\cdot}0007 \\ \\ D=3048{\cdot}1746 \\ \pm{\cdot}0007 \\ \\ E=3048{\cdot}1821 \\ \pm{\cdot}0007 \end{array}\right\} \begin{array}{l} +0{\cdot}033076\theta+0{\cdot}0000166\theta^2 \\ \pm\ {\cdot}000025\ \pm\ {\cdot}0000019 \end{array}$$

Probable error of a single comparison :
microns
±2·24

where, as before, $\theta=t^\circ-23^\circ$.

30. The probable errors are very nearly equal in the two sets of comparisons. If, however, we examine the distribution of the residual errors (given in column 11 of the preceding tables), and compare with the theoretical distribution, we find a much better agreement between theory and observation in the 1906 comparisons than in those of 1905. Comparison of residual errors.

1905 Comparisons.		
Between microns.	No. of Errors.	
	Theoretical.	Actual.
0 & 1	22	18
1 & 2	20	31
2 & 3	16	10
3 & 4	12	12
4 & 5	8	10
5 & 6	5	3
6 & 7	2	2
over 7	2	1

1906 Comparisons.		
Between microns.	No. of Errors.	
	Theoretical.	Actual.
0 & 1	18	22
1 & 2	16	16
2 & 3	14	13
3 & 4	10	10
4 & 5	7	7
5 & 6	5	2
6 & 7	3	3
over 7	3	3

Moreover, as has been stated (paragraph 24) the comparisons of 1905 were made under conditions quite unsuitable for accurate work. The results may, therefore, reasonably be rejected.

Comparison with 1888 results.

31. The 1906 results agree very closely, in the sum of the bars, with the original results of 1888. The equations of the bars, upon which the lengths of the bases depend, are given in Table A of Geodetic Survey Report, Volume I., p. 42. For purposes of comparison, they may be put in the following equivalent form :—

$$\begin{aligned} & \qquad\qquad\text{mm.} \\ A &= 3048{\cdot}1662 + 0{\cdot}033146\theta + 0{\cdot}000002830\theta^2 \\ B &= 3048{\cdot}1616 + 0{\cdot}033081\theta + 0{\cdot}000004244\theta^2 \\ C &= 3048{\cdot}1852 + 0{\cdot}033414\theta + 0{\cdot}000009146\theta^2 \\ D &= 3048{\cdot}1734 + 0{\cdot}032628\theta + 0{\cdot}000005757\theta^2 \\ E &= 3048{\cdot}1862 + 0{\cdot}033163\theta - 0{\cdot}000007546\theta^2 \end{aligned}$$

Ground standards.

32. The ground standards for the bases were always 480 feet in length. The Belfast, Ottoshoop, and Wepener ground standards were measured in 12 length of the bars B, C, D, and E ; the Kroonstad and Houts River standards in 9 lengths of the 5 bars + A + B + E.

Put I for results of the original comparisons of 1888,
„ II for results of 1906 comparisons (separate coefficients),
„ III for results of 1906 comparisons (same coefficient),
S = 480 feet.

Then from Belfast, Ottoshoop, and Wepener,

$$S = \begin{cases} \text{I} \ldots\ldots\ 146312{\cdot}4768 + 1{\cdot}587432\theta + 0{\cdot}001219\theta^2 \\ \text{II} \ldots\ldots\ 146312{\cdot}4720 + 1{\cdot}587348\theta + 0{\cdot}000806\theta^2 \\ \text{III} \ldots\ldots\ 146312{\cdot}4756 + 1{\cdot}587648\theta + 0{\cdot}0007945\theta^2 \end{cases} \quad \text{mm.}$$

$$\begin{aligned} \text{II} - \text{I} &= -0{\cdot}0048 - 0{\cdot}000084\theta - 0{\cdot}0004129\theta^2 \quad \text{mm.} \\ \text{III} - \text{I} &= -0{\cdot}0012 + 0{\cdot}000216\theta - 0{\cdot}0004248\theta^2 \end{aligned}$$

For Kroonstad and Houts River,

$$S = \begin{cases} \text{I} \ldots\ldots\ 146312{\cdot}3674 + 1{\cdot}588278\theta + 0{\cdot}0009773\theta^2 \\ \text{II} \ldots\ldots\ 146312{\cdot}3440 + 1{\cdot}588392\theta + 0{\cdot}0008155\theta^2 \\ \text{III} \ldots\ldots\ 146312{\cdot}3407 + 1{\cdot}587648\theta + 0{\cdot}0007945\theta^2 \end{cases} \quad \text{mm.}$$

$$\begin{aligned} \text{II} - \text{I} &= -0{\cdot}0234 + 0{\cdot}000114\theta - 0{\cdot}0001618\theta^2 \quad \text{mm.} \\ \text{III} - \text{I} &= -0{\cdot}0267 - 0{\cdot}000630\theta - 0{\cdot}0001828\theta^2 \end{aligned}$$

Discordances old *v.* new.

33. The following table exhibits the discordances in S between new and old results :—

Base.	Mean Temperature of Bars during Measurement.	θ	II − I.		III − I.	
			Microns.	Millionths of Length.	Microns.	Millionths of Length.
	° C.	°				
Belfast..	14·0	−9·0	−37	0·250	−37	0·250
Ottoshoop	22·8	−0·2	− 5	0·034	− 1	0·007
Wepener	26·8	+3·8	−11	0·075	− 7	0·012
Kroonstad	25·0	+2·0	−24	0·164	−29	0·200
Houts River	17·3	−5·7	−29	0·200	−29	0·200

FORMULÆ AND METHODS OF COMPUTATION.

34. Approximate formulæ of spherical trigonometry (see generally "Geodesy," by Colonel A. R. Clarke, C.B.)—

A. In the right-angled triangle ABC, in which A is the right angle, suppose the case of c being small, in which case C and 90° − B are small, we have—

$$\frac{\tan C}{\tan c} = \frac{1}{\sin b},$$

put $k = \frac{1}{\sin b}$, and expand the tangents.

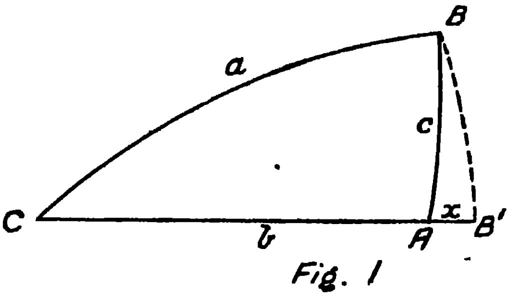


Fig. 1

Then,

$$C + \tfrac{1}{3}C^3 + \tfrac{2}{15}C^5 + \ldots\ldots = k\left(c + \tfrac{1}{3}c^3 + \tfrac{2}{15}c^5 + \ldots\ldots\right).$$

Let

$$C = kc + lc^3 + mc^5,$$

then

$$C = kc + \left(\tfrac{1}{3}k^3 + l\right)c^3 + \left(\tfrac{2}{15}k^5 + k^2l + m\right)c^5 = kc + \tfrac{1}{3}kc^3 + \tfrac{2}{15}kc^5,$$

from which, by the method of indeterminate coefficients,

$$l = \tfrac{1}{3}(k - k^3), \quad m = \tfrac{2}{15}(k - k^5) - \tfrac{1}{3}(k^3 - k^5),$$

$$\therefore \quad C = ck\left\{1 + \frac{c^2}{3}(1 - k^2) + \frac{c^4}{15}(1 - k^2)(2 - 3k^2)\right\}$$

Replacing the value of k, and bearing in mind that

$$\sin(b + x) = \sin b\,(1 + x\cot b),$$

when the square of x is neglected, we find, omitting terms in c^5,

$$C = \frac{c}{\sin\left(b + \tfrac{1}{3}c^2\cot b\right)}.$$

B. Put 90° − B = V, then

$$\sin V = \sin C \,.\, \cos b,$$

$$V - \tfrac{1}{6}V^3 + \tfrac{1}{120}V^5 - \ldots \quad = \cos b\left(C - \tfrac{1}{6}C^3 + \tfrac{1}{120}C^5 - \ldots\right),$$

put $k = \cos b$, and let $V = kC - lC^3 + mC^5$.

Then, neglecting terms in C^5,

$$V = kC - \tfrac{1}{6}k(1 - k^2)C^3,$$

$$= C \,.\, \cos b\left(1 - \tfrac{1}{6}\sin^2 bC^2\right),$$

putting for C^2 its value

$$\frac{c^2}{\sin^2\left(b + \tfrac{1}{3}c^2 \,.\, \cot b\right)},$$

we get

$$V = C \,.\, \cos b\left\{1 - \tfrac{1}{6}\left(1 - \tfrac{2}{3}C^2 \,.\, \cot^2 b\right)c^2\right\}$$

or, neglecting terms in c^5,

$$V = C \,.\, \cos\left(b + \tfrac{1}{6}c^2 \,.\, \cot b\right)$$

C. Again, a exceeds b by a small quantity, x say, then

$$\cos(b + x) = \cos b \,.\, \cos c,$$

$$\cos x - \tan b \,.\, \sin x = \cos c,$$

$$1 - \frac{x^2}{2} + \ldots - x \tan b + \ldots = 1 - \frac{c^2}{2} + \frac{c^4}{24} \ldots,$$

put for x^2 its approximate value $(\frac{1}{2}c^2 \,.\, \cot b)^2$, then

$$x = \tfrac{1}{2}c^2 \,.\, \cot b - \tfrac{1}{24}c^4 \cot b\,(1 + 3\cot^2 b) = \eta.$$

D. The solution of the triangle then is this—

$$\left.\begin{aligned} a - b &= \eta \\ C &= \frac{c}{\sin(b + \frac{2}{3}\eta)} \\ 90^\circ - B &= C \,.\, \cos(b + \tfrac{1}{3}\eta) \end{aligned}\right\} \text{I.}$$

E. In the case in which s, the side opposite C, is small, but A not a right angle, let $BB' = c$ be the perpendicular on CA, and $CN = CB$; then the spherical excess of the triangle ABB′ is

$$e = \tfrac{1}{2}s^2 \,.\, \sin A \,.\, \cos A.$$

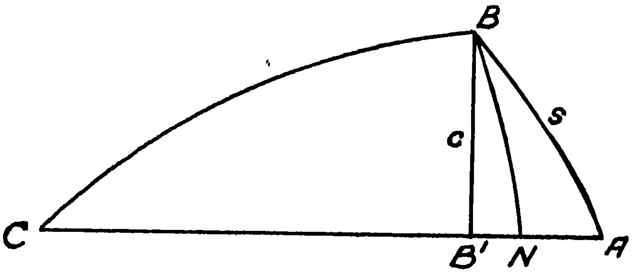


Fig. 2

F. And by Legendre's theorem, see paragraph 36, in the right angled triangle AB′B—

$$\text{Angle } ABB' = 90^\circ - A + e,$$

$$BB' = c = s \,.\, \sin(A - \tfrac{1}{3}e),$$

$$B'A = s \quad \cos(A - \tfrac{2}{3}e).$$

G. Put $b' = CB'$, then,

$$C = \frac{c}{\sin(b' + \frac{2}{3}\eta)} \quad \text{(from I)},$$

$$= \frac{s \,.\, \sin(A - \frac{1}{3}e)}{\sin(b' + \frac{2}{3}\eta)}.$$

H. $B = 90^\circ - V + ABB'$

$$= 180^\circ - \{A + C \,.\, \cos(b' + \tfrac{1}{3}\eta) - e\}.$$

I. And the solution of the triangle is

$$\left.\begin{aligned} a &= b - s\cos(A - \tfrac{2}{3}e) + \eta, \\ C &= \frac{s \,.\, \sin(A - \frac{1}{3}e)}{\sin(a - \frac{1}{3}\eta)}, \\ B &= 180^\circ - \{A + C \,.\, \cos(a - \tfrac{2}{3}\eta) - e\}, \\ &\text{where} \\ \eta &= \tfrac{1}{2}s^2 \,.\, \sin A \,.\, \cot b' \,\{1 + \tfrac{1}{12}s^2 \,.\, \sin^2 A\,(1 + 3\cot b')\}, \\ e &= \tfrac{1}{2}s^2 \,.\, \sin A \,.\, \cos A, \end{aligned}\right\} \text{II.}$$

Formulæ I and II are the fundamental formulæ for the calculation of spheroidal co-ordinates and bearings, of latitudes, longitudes, and azimuths, and for the transformation from one system to the other.

35. *Radii of Curvature and Triangles on the Earth's Surface.*—The principal radii of curvature are in the direction of the meridian and perpendicular to the same; denoting these by R_m and R_n, respectively, we have with Clarke's elements ("Geodesy," p. 321) in latitude ϕ,

$$R_m \text{ (in feet)} = 20890564 - 106960 \cos 2\phi + 228 \cos 4\phi,$$
$$R_n \text{ (in feet)} = 20961932 - 35775 \cos 2\phi + 46 \cos 4\phi.$$

The radius of curvature for an arc of the meridian is the radius for the centre of the arc, *i.e.*, for $\frac{1}{2}(\phi + \phi')$ where ϕ and ϕ' are the latitudes of the extremities of the arc. The radius for an arc perpendicular to the meridian is the radius for the latitude of the foot of the perpendicular. For small arcs inclined to the meridian a mean radius ($R = \sqrt{R_m R_n}$) is used.

To facilitate the computations, the logarithms of the following quantities were tabulated; they are given in Tables Q and R at the end of this volume—

$$M = (R_m \sin 1'')^{-1}, \qquad N = (R_n \sin 1'')^{-1},$$

$$\begin{pmatrix} \text{Log } M = 7{\cdot}994477820 + {\cdot}002223606 \cos 2\phi - {\cdot}000001897 \cos 4\phi \\ \text{Log } N = 7{\cdot}992994150 + {\cdot}000741202 \cos 2\phi - {\cdot}000000632 \cos 4\phi \end{pmatrix}$$

"Geodesy," p. 322

$$E = \tfrac{1}{2}M \,.\, N \,.\, \sin 1'' = (2R^2 \sin 1'')^{-1},$$

$$k = E \,.\, \sin 1'' = (2R^2)^{-1},$$

$$F = \frac{1 + 3\tan^2\phi}{12R^2} \left(\log \frac{1}{12R^2} \text{ taken} = 4{\cdot}281\right),$$

$$G = \frac{2}{3} \cdot \frac{N}{M} \tan\phi \,.\, \sin 1'',$$

$$H = \frac{1}{3} \cdot \frac{N}{M} \cot\phi \;\; \sin 1'',$$

$$J = E \,.\, \sec^2\phi \,.\, \sin 1'' - F,$$

$$P = (G + H),$$

$$C = \frac{1}{6N} \,.\, \sin^2\phi \,.\, \cos\phi \,.\, \sin^2 1'',$$

36. *Spheroidal Triangles and Spherical Excess.*—Spheroidal triangles are calculated as spherical triangles by Legendre's theorem, the spherical excess being obtained from the formula

$$e'' = 2 \times \text{Area of triangle (in square feet)} \times E,$$

where E is taken for the mean latitude of the triangle.

37. *Rectangular Spheroidal Co-ordinates* :—

A. The X-axis of co-ordinates is a meridian, and the Y-axis is a great circle, through the origin, perpendicular to the X-axis. Thus the prolongations of the ordinates of points intersect in the two points on the equator which are the poles of the X-axis. Bearings or angles of direction are measured from small circles parallel to the X-axis, through 360° from south through west. Thus positive values of Y and X increase towards the west and south, respectively.

In Fig. 3 XX′ is the X-axis, O the origin, C the pole. The co-ordinates of A are $Y_A = AP_1$; $X_A = OP_1$. The co-ordinates of B are $Y_B = BP_2$, $X_B = OP_2$.

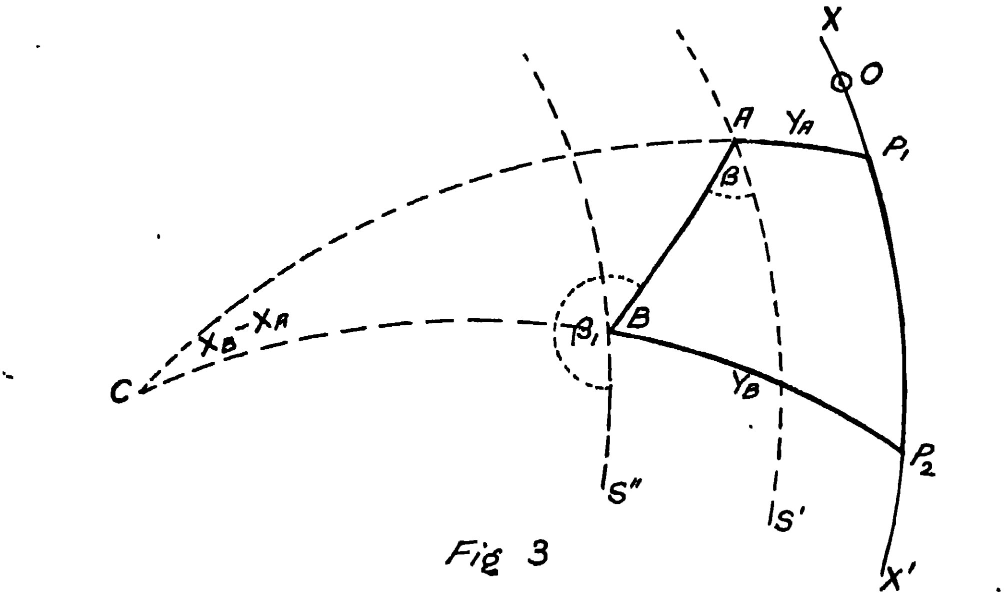


Fig 3

The bearing A to B (β) is the angle S′AB, the bearing B to A (β_1) is the angle S″BA.

B. Calculation of co-ordinates :—

Given the co-ordinates (Y_A, X_A) of a point A, the distance (s) and the bearing (β) of a point B, to find the co-ordinates (Y_B, X_B) of B, and the bearing (β_1) of A at B.

The arcs Y_A, Y_B, $(X_B - X_A)$ are invariably small in comparison with the quadrants.

C. In Formulæ II put $C = X_B - X_A$, $b = 90° - Y_A$, $a = 90° - Y_B$, $A = \beta - 90°$, $B = 90° - \beta$.

Then

$$Y_B = Y_A + s \,.\, \sin(\beta + \tfrac{2}{3}e) + \eta \quad \text{(From the 1st of Formulæ II)},$$

$$e = \tfrac{1}{2}s^2 \,.\, \sin\beta \,.\, \cos\beta,$$

$$\eta = \tfrac{1}{2}s^2 \cos^2\beta \,.\, \tan(Y_B + \eta) = \tfrac{1}{2}s^2 \cos^2\beta \,.\, Y_B \text{ with sufficient accuracy.}$$

$$\therefore \quad Y_B' = Y_A' + s \,.\, \sin\beta\,(1 + \tfrac{1}{3}s^2\cos^2\beta) - \tfrac{1}{2}s^2 \,.\, \cos^2\beta \,.\, Y_B.$$

In the last term on the right hand side put for Y_B its approximate value

$$Y_A + s \,.\, \sin\beta.$$

Then

$$Y_B = Y_A + s \,.\, \sin\beta - \tfrac{1}{6}s^3 \,.\, \sin\beta \,.\, \cos^2\beta + \tfrac{1}{2}s^2 \,.\, \cos^2\beta \,.\, Y_A.$$

Let

$$s \,.\, \sin\beta = n, \qquad s \,.\, \cos\beta = m.$$

Then

$$Y_B = Y_A + n + \tfrac{1}{2}m^2 \,.\, Y_A - \tfrac{1}{6}n \,.\, m^2.$$

D. From the 2nd of Formulæ II :—

$$X_B - X_A = \frac{s \,.\, \cos(\beta + \frac{1}{3}e)}{\cos(Y_B + \frac{1}{3}\eta)}$$

$$= s \,.\, \cos\beta\,(1 - \tfrac{1}{6}s^2 \sin^2\beta)\,(1 + \tfrac{1}{2}Y_B^2) \text{ very nearly}$$

$$= m + \tfrac{1}{2}m\,Y_B^2 - \tfrac{1}{6}mn^2.$$

E. From the 3rd of Formulæ II :—

$$\beta_1 = \beta - 180^\circ - (X_B - X_A)\sin(Y_B + \tfrac{2}{3}\eta) + e,$$

$$= \beta - 180^\circ - (X_B - X_A)(Y_A + n) + e,$$

$$= \beta - 180^\circ - (X_B - X_A)\ Y_A - \tfrac{1}{2}\,.\,n\,.\,m.$$

F. Therefore, on the earth's surface :—

$$\left.\begin{aligned} Y_B &= Y_A + n + km^2 Y_A - \tfrac{1}{3}km^2 n,\\ X_B &= X_A + m + km\ Y^2{}_B - \tfrac{1}{3}kmn^2,\\ \beta_1 &= \beta \pm 180^\circ - \frac{2k\,(X_B - X_A)\,Y_A}{\sin 1''} - \frac{kmn}{\sin 1''},\\ \text{where } n &= s\,.\,\sin\beta,\\ m &= s\,.\,\cos\beta,\\ k &= \frac{1}{2R^2} \end{aligned}\right\}\text{III.}$$

38. *Computation of latitudes, longitudes and azimuths* :—

A. Given the latitude (ϕ) and the longitude (L) of A, the distance AB (in feet)=S, and the azimuth (α) of B at A, to find the latitude (ϕ') and the longitude (L′) of B and the azimuth (α') of A at B.

In Fig. 2—

$$CA = b = 90^\circ - \phi$$

$$CB = a = 90^\circ - \phi'$$

$$A = \alpha$$

$$B = 360^\circ - \alpha'$$

$$AB = s.$$

B. Substituting these values in Formulæ II, putting ϕ_1 for the latitude of B′, the foot of the perpendicular, dividing the arcs by their radii, and converting into seconds, we get :—

$$\left.\begin{aligned} e'' &= E\,.\,s^2\,.\,\sin\alpha\,.\,\cos\alpha,\\ \eta'' &= e\,.\,\tan\alpha\,.\,\tan\phi_1.\\ &\text{The second term in } \eta \text{ may be neglected.}\\ (\phi' - \phi)'' &= M\,.\,s\,.\,\cos(\alpha - \tfrac{2}{3}e) - \eta,\\ (L' - L)'' &= N\,.\,s\,.\,\sin(\alpha - \tfrac{1}{3}e)\sec(\phi + \tfrac{1}{3}\eta),\\ (\alpha' - \alpha)'' &= \pm 180^\circ + (L' - L)\sin(\phi + \tfrac{2}{3}\eta) - e, \end{aligned}\right\}\text{IV.}$$

To get the latitude of ϕ_1 (the foot of the perpendicular) a preliminary computation must be made of $(\phi_1 - \phi)'' = M\,.\,s\,.\,\cos\alpha$.

The azimuths are taken from south by west from 0° to 360°, thus south latitudes and west longitudes are positive.

39*a*. *To transform rectangular spheroidal co-ordinates and bearings into latitude, longitude and azimuth :—*

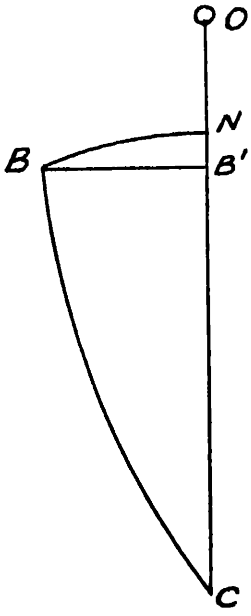


Fig. 4.

A. In Fig. 4 let O be the origin of co-ordinates, C the elevated pole of the earth, BB′ a perpendicular on OC from B, CN = CB.

Then the co-ordinates of B are—

$$Y = BB', \qquad X = OB'.$$

Denote the latitude and longitude of the origin by ϕ_0 and L_0; the latitude and longitude of B by ϕ and L; the latitude of B′ by ϕ_1; the difference of longitude $(L - L_0 = C)$ by λ.

Then

$$\phi_1 = 90^\circ - CB' = \phi_0 + x,$$
$$\phi = 90 - CN = \phi_1 - NB'.$$

B. In Formulæ I, put $90^\circ - \phi$ for a, $90 - \phi_1$ for b, Y for c and λ for C;

Then

$$\phi_1 - \phi = NB' = \eta = \tfrac{1}{2} Y^2 \tan \phi_1 - \tfrac{1}{24} Y^4 \tan \phi_1 (1 + 3 \tan^2 \phi_1),$$
$$\lambda = \frac{Y}{\cos (\phi_1 - \frac{2}{3} \eta)},$$

and (since azimuth = bearing at B′) at B, $\alpha - \beta = \lambda \,.\, \sin (\phi_1 - \frac{1}{3} \eta)$.

C. Thus, in seconds :—

$$\left.\begin{aligned} (\phi_1 - \phi_0)'' &= XM, \\ (\phi - \phi_1)'' &= -\eta = -Y^2 E \,.\, \tan \phi_1 (1 - Y^2 F), \\ (L - L_0)'' &= \lambda = \frac{YN}{\cos \phi_1} (1 - G \,.\, \eta), \\ (\alpha - \beta)'' &= \lambda \,.\, \sin \phi_1 (1 - H \,.\, \eta), \\ &= YN \,.\, \tan \phi_1 (1 - P\eta), \\ \text{where } \eta'' &= Y^2 E \,.\, \tan \phi_1. \end{aligned}\right\} \text{V.}$$

D. If the difference of latitude is large the arc may be divided into n sections $(x_1 + x_2 + x_3 + \ldots + x_n = X)$ and M taken for the mid-latitude of each section. The origin of co-ordinates, in this survey, is always on the 25th parallel; and a table was formed of the distances X for every minute of latitude. These distances were computed from Clarke's formula—

$$1^\circ \text{ lat. (in feet)} = 364609{\cdot}12 - 1866{\cdot}72 \cos 2\phi + 3{\cdot}98 \cos 4\phi$$

("Geodesy," p. 322).

The distances from the 25th parallel are given for every 5′ of latitude between 21° and 33°, in Table S at the end of this volume.

Example—

$$\begin{aligned} X &= +\,2669543{\cdot}9 \\ X \text{ for } 32^\circ\ 20' \text{ (from Table S)} &\ \underline{+\,2666419{\cdot}6} \\ x &= \quad +\,3124{\cdot}3\,; \end{aligned}$$

Then $\phi_1 = 32^\circ\ 20' + x\,M$.

39*b*. *To transform latitude, longitude and azimuth into spheroidal co-ordinates and bearings :—*

A. In the triangle BB′C (Fig. 4) right-angled at B′, BB′ $=$ Y, CB $= 90° - \phi$, and C $= \lambda$,

$$\sin Y = \cos \phi \,.\, \sin \lambda\,;$$

or approximately

$$Y = \lambda \,.\, \cos \phi - \frac{\lambda^3}{6} \,.\, \sin^2 \phi \,.\, \cos \phi.$$

B. This is a very close approximation to Y, and is always sufficient for the computation of η. We have then from the formulæ V :—

$$\begin{aligned} \eta &= Y^2\, E \tan \phi_1 \,(1 - Y^2\, F), \\ &= Y^2\, E \tan \phi \,(1 + Y^2\, E \,.\, \sec^2 \phi \,.\, \sin 1'' - Y^2\, F), \\ &= Y^2\, E \tan \phi \,(1 + J Y^2), \end{aligned}$$

$$\phi_1 = \phi + \eta,$$

$$X = \frac{\phi_1 - \phi_0}{M},$$

$$Y = \frac{\lambda \,.\, \cos \phi_1}{N\,(1 - G\,\eta)} = \frac{\lambda}{N} \,.\, \cos \phi_1 \,(1 + G\,\eta).$$

C. Collecting these formulæ :—

$$\left.\begin{aligned} Y &= \frac{\lambda}{N} \cos \phi - \lambda^3\, C \ldots \text{1st (very close) approximation,} \\ \eta &= Y^2\, E \,.\, \tan \phi \,(1 + J\, Y^2), \\ \phi_1 &= \phi + \eta, \\ X &= \frac{\phi_1 - \phi_0}{M}, \\ Y &= \frac{\lambda \cos \phi_1}{N} \,.\, (1 + G\,\eta), \end{aligned}\right\} \text{VI.}$$

$\alpha - \beta$ is given by the 4th and 5th Formulæ of V.

40. *Examples of Transformation of Co-ordinates.*

Lats., Longs., and Azimuths from Co-ordinates.

STATION, Paardekop II. $\phi_0 = 25°$ $L_0 = - 26°$. No.

Y	− 715582·5
Log Y	5·8546597
Log x	2·9787511
Log M	7·9958184
	0·9695645
Nat No.	9·323
ϕ_1 =	26° 32′ 50″·677
L. Sin ϕ_1	9·6502474
L. Cos ϕ_1	9·9516118
L. tan ϕ_1	9·6986357

X	+562402·4
[X] 26° 33′	+563343·75
x	− 941·35

Log Y²	1·7093194
Log E	0·37380
L. tan ϕ_1	9·6986357
Log η	1·7817551
Log Y²	1·709
Log F	4·534
Log η'	8·025
η	− 60·500
η'	+ ·011
	− 60·489

ϕ = 26° 31′ 50″·188

Bearing to Observatory Hill (J'burg.)

β = 164° 47′ 27″·90.

Log Y	5·8546597
Log N	7·9984395
L. Sec. ϕ_1	0·0483882
Log λ_1	3·8964874
Log η	1·78175
Log G	4·20572
Log λ_2	9·88396
λ_1	−7879·296
λ_2	+ ·765
λ	−7878·531

L = − 28° 11′ 18″·531

Log Y N	3·8480992
L. tan ϕ_1	9·6986357
Log γ_1	3·5467349
Log η	1·7817
Log P	4·6833
Log γ_2	0·0117
γ_1	−3521·559
γ_2	+ 1·028
γ	−3520·531

α = 163° 48′ 47″·37

Co-ordinates from Lats. and Longs.

STATION, Paardekop II. $\phi_0 = 25°$ $L_0 = - 26°$. No.

	°	′	″
ϕ	26	31	50·188
L −	28	11	18·531
λ −	2	11	18·531
λ −			7878·531

Log λ	− 3·8964452
L. Cos ϕ	9·9516754
	3·8481206
Log N	7·9984398
Log (1)	5·8546808
Log λ^3	1·6893
Log C	9·8508
Log (2)	1·5401
Nat. No. (1)	−715617·2
„ „ (2)	− 34·7
[Y] =	−715582·5
Log [Y]	5·8546597

Log [Y]²	1·7093194
Log E	0·373795
L. tan ϕ	9·6983170
Log (1)	1·7814814
Log [Y]²	1·7093
Log J	5·0408
Log (2)	8·5815
Nat No. (1)	+ 60·4549
„ „ (2)	+ ·0340
η =	+ 60·4889
ϕ	26 31 50·188
ϕ'	26 32 50·677

Log λ	− 3·8964452
L. Cos ϕ'	9·9516118
	3·8480570
Log N	7·9984395
Log (1)	5·8546175
Log η	1·78175
Log G	4·20572
Log (2)	1·84209
Nat No. (1)	−715518·0
„ „ (2)	− 69·5
Y =	−715582·5

Log Y	− 5·8546597
Log N	7·9934395
L. tan ϕ'	9·6986357
Log (1)	3·5467349
Log η	1·7817
Log P	4·6833
Log (2)	0·0117
Nat No. (1)	− 3521·559
„ „ (2)	+ 1·027
$\alpha - \beta$	− 3520·532
x =	2′ 50″·677
Log x	2·2321750
Log M	7·9958186
	4·2363614
Nat. No.	+ 17233·02
X for 26° 30′	545169·45
X =	+ 562402·47

41. *Adjustment of Bases and Circuits.*—The general method of treatment for the closure of bases and of circuits is fully exhibited in Vol. II of the Report of the G.T. Survey of India. The method adopted in the present Survey differs from that of the Indian Survey in that, whereas, in the latter the errors in closure are expressed in differences of latitudes, longitudes, and azimuths—and consequently the factors employed in the adjustment depend on the differentials of these co-ordinates and angles—in the former the errors are expressed in differences of rectangular spheroidal co-ordinates and bearings, and the factors in terms of their differentials. Where possible, the description of the method (word for word, or with such modifications as are necessary) and the notation of the Indian G.T.S. Report are used in the present discussion.

42. The circuits having been computed with corrected values of the observed angles, which satisfy the geometrical conditions of each figure contained in the original compound chain of triangles, the simple chains are formed of single triangles by selection from the figures. Let x, y, and z now represent the residual errors of the figurally corrected angles X, Y, Z, the most probable values of which have to be determined in such a manner as to satisfy the circuit conditions, without disturbing the geometrical conditions of the triangles; let, in general, x appertain to a flank angle, and y and z to angles of continuation. Base errors are functions of the residual errors of the angles of continuation; $\mathfrak{X}$, $\mathfrak{Y}$, and bearing errors are functions of the residual errors of the flank angles as well as of the angles of continuation; therefore, whenever an x occurs it is eliminated by substituting $-(y+z)$ for it. (In order to distinguish the X's and Y's of angles from those of co-ordinates, the former are printed in Roman, and the latter in Old English capitals.)

43. *The Base Equations.*—The base equations are of the ordinary form of side equation. If we put R_m for the ratio of the second base to the first, then the value of the ratio which is given by the triangulation, through a chain of m triangles, is

$$R_m = \frac{\sin Y_1 \,.\, \sin Y_2 \ldots\ldots \sin Y_m}{\sin Z_1 \,.\, \sin Z_2 \ldots\ldots \sin Z_m}.$$

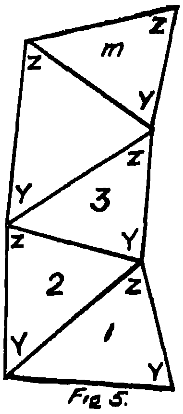


Fig 5.

Differentiating, and putting

$$dY = y, \quad dZ = z, \quad \cot Y = \beta, \quad \cot Z = \gamma,$$

we have

$$dR_m = R_m \{\beta_1 y_1 - \gamma_1 z_1 + \ldots\ldots + \beta_m y_m - \gamma_m z_m\} \sin 1'',$$

or

$$(\beta_1 y_1 + \ldots + \beta_m y_m) - (\gamma_1 z_1 + \ldots + \gamma_m z_m) = \frac{dR_m}{R_m \sin 1''} = E_B \ldots\ldots \text{(ia)}.$$

In the adjustment of this survey the bases were closed on each other through each circuit completely; this is clearly equivalent to the closure in length of a line upon itself in each circuit.

44. *The Geodetic Equations.*—The equations remaining to be considered are for the closures in $\mathfrak{Y}$, $\mathfrak{X}$, and bearing. The formulæ which are used in calculating the differences of $\mathfrak{Y}$ and $\mathfrak{X}$, and the reverse bearing of any two stations, whose distance and forward bearing are known, are given by Formulæ III, paragraph 37. We have now to express the variations in any summations of $\Delta\mathfrak{Y}$'s or of $\Delta\mathfrak{X}$'s from the first to the last station of a chain of triangles, and in the bearing of a side at the last station, which will arise from small changes in the angles. In differentiating the Formulæ III with respect to s and A, the first terms only, of the first and second equations, need be regarded; for the quantities represented by the other terms are

always small, and their differentials are very minute fractions of these small quantities. Thus we have—

$$\left.\begin{aligned} d\,\Delta\mathfrak{Y} &= dn = d\text{A}\,.\,m\,.\,\sin 1'' + ds\,.\,\sin \text{A} \\ d\,\Delta\mathfrak{X} &= dm = d\text{A}\,.\,n\,.\,\sin 1'' + ds\,.\,\cos \text{A} \\ d\,\Delta\text{A} &= 0 \end{aligned}\right\}\text{IV},$$

where A is written for β in order to distinguish between bearing and cot Y. (*See* following paragraph.)

45. In the diagram, Fig. 6, let **1** be the origin of a chain of n triangles closing a circuit; let **1**, **2** . . . . m be stations on the line of traverse—indicated by the dotted line running parallel to the sides on one flank of the chain—which connects **1** with any station in advance. Let **1**r be the initial and closing line for bearing. Considering this line a base the side opposite the angle Y, in triangle 1 is the line of continuation, and this side in turn becomes the base for triangle 2, and so on. Suppose that, as in the diagram, the traverse line is chosen so that a positive *correction* to an angle on the line of traverse gives a positive increase to the bearing of the side in the traverse. In any, the k^{th}, triangle put

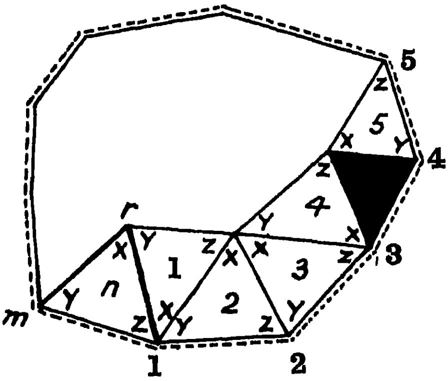


Fig. 6.

$$\cot \text{X}_k = \alpha_k, \quad \cot \text{Y}_k = \beta_k, \quad \cot \text{Z}_k = \gamma_k \quad . \quad . \quad . \quad . \quad . \quad \text{(i)}$$

For any side in the line of traverse between the stations t and $t+1$ put

$$s = s_t, \quad m \sin 1'' = p_t, \quad n\,.\,\sin 1'' = q_t \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}$$

and let the summations of the p's and q's from the closing station **1** (in reverse order to the direction of the traverse) to the station t, be P_t and Q_t, respectively. That is, let

$$(p_m + p_{m-1} + \ldots . + p_{t+1} + p_t) = \text{P}_t \quad . \quad . \quad . \quad . \quad . \quad . \text{(iii)}$$

$$(q_m + q_{m-1} + \ldots . + q_{t+1} + q_t) = \text{Q}_t \quad . \quad . \quad . \quad . \quad . \quad . \text{(iv)}$$

We may now consider the effects of changes in the angles, on the bearing of the closing line, and on the co-ordinates of the closing station, when carried through the triangulation.

46. *Effect of changes in the Angles on the Final Bearing.*—It will readily be seen that changes in the angles on the line of traverse have their full effect on the final bearing of the closing line (this indeed is shown by the third of Formulæ VI). Thus when Y, or Z, is on the line of traverse, the effect on the closing line is $-y$ or $-z$ (remembering that y and z are the *errors* of Y and Z); when X is on the line of traverse the effect is $+(y+z)$. Therefore the total effect of all the changes in the angles is

$$y_1 + z_1 - y_2 - z_2 + \ldots . + y_n + z_n.$$

If then the error of closure in bearing is E_A, the equation in A is

$$\pm(y_1 + z_1) \pm (y_2 + z_2) \pm \ldots . \pm (y_n + z_n) = \text{E}_\text{A} \quad . \quad . \quad . \quad . \quad \text{(v)}$$

That is, the coefficients of y and z are always ± 1 in the bearing equations.

47. *Effect of changes in bearing on the* $\mathfrak{Y}$ *and* $\mathfrak{X}$ *of the closing station.*—At any station t the change in the bearing of the side t to $t+1$ is the change in t to $t-1$ plus the sum of the corrections to the angles at t. Put

$$\left.\begin{aligned} &[yz]_1 \text{ for the sum of the } \textit{errors} \text{ of the angles at } \mathbf{1} \\ &[yz]_t \text{ for the sum of the } \textit{errors} \text{ of the angles at } t \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad \text{(vi)}$$

Now the effect of the *corrections* $-[yz]_1$ is carried through all the sides of the traverse from station **1**, *i.e.* through **1** to **2**, **2** to **3** . . . . m to **1**. And

$-[yz]_t$ affects all the sides between t and the closing station. The total effects of the changes in the angles, on the closing station are therefore (*see* Formulæ VI and (ii), (iii), (iv), and (vi)), on

$$\mathfrak{Y}_{m+1} \dots\dots -\{[yz]_1(p_1+p_2+\dots\dots+p_m)+[yz]_2(p_2+\dots\dots+p_m)+\dots\dots$$
$$+[yz]_t(p_t+\dots\dots+p_m)+\dots\dots+[yz]_m(p_m)\}$$
$$=-\{[yz]_1 P_1+\dots\dots+[yz]_m P_m\} \quad \dots\dots \quad \text{(vii)}$$

Similarly the effect on $\mathfrak{X}_{m+1}$ is

$$+\{[yz]_1 Q_1+\dots\dots+[yz]_m Q_m\} \quad \dots\dots\dots \quad \text{(viii)}$$

48. *Effect of changes in the sides of the line of traverse on the* $\mathfrak{Y}$ *and* $\mathfrak{X}$ *of the closing station.*—A. The effects of any change *in a line of continuation* are carried through the chain, from the station at the end of the line, to the closing station. Thus if any, the k^{th}, triangle has no side in the line of traverse, but only an angle at the station t, and we put s_c for the side of continuation in the triangle k, we have (when Z is opposite the base and Y opposite the side of continuation)

$$\frac{ds_c}{s_c}=(z_k\gamma_k-y_k\beta_k)\sin 1'',$$

and the effect on a side s_t in any following triangle is,

$$ds_t=s_t(z_k\gamma_k-y_k\beta_k)\sin 1'',$$

therefore the effects of changes in the angles of k, on the closing station, are (*see* Formulæ VI and (i) to (iv)), on

$$\mathfrak{Y}_{m+1}\dots\dots(s_t\sin A_t+s_{t+1}\sin A_{t+1}+\dots\dots+s_m\sin A_m)(z_k\gamma_k-y_k\beta_k)\sin 1'',$$

that is, since

$$s_t\sin A_t=n_t,\quad n_t\sin 1''=q_t\quad\text{and}\quad(q_t+\dots\dots+q_m)=Q_t,$$

the effect on $\mathfrak{Y}_{m+1}$ is

$$(z_k\gamma_k-y_k\beta_k)\,Q_t \quad \dots\dots\dots\dots \quad \text{(ix)}$$

Similarly the effect on $\mathfrak{X}_{m+1}$ is

$$(z_k\gamma_k-y_k\beta_k)\,P_t \quad \dots\dots\dots\dots \quad \text{(x)}$$

B. If the triangle k has a side in the line of traverse, between the stations t and $t+1$, we have

$$\frac{d\,.\,s_t}{s_t}=(z_k\gamma_k-x_k\alpha_k)\sin 1''=\{z_k(\alpha_k+\gamma_k)+y_k\alpha_k\}\sin 1'',$$

and

$$\frac{d\,.\,s_c}{s_c}=(z_k\gamma_k-y_k\beta_k)\sin 1''.$$

Therefore the effects of changes in the angles of k, on the closing station, are

$$\text{On } \mathfrak{Y}_{m+1}\ \dots\dots \left\{\begin{array}{l}\{z_k(\alpha_k+\gamma_k)+y_k\alpha_k\}\{Q_t-Q_{t+1}\}\\ +\{z_k\gamma_k-y_k\beta_k\}\,Q_{t+1}\end{array}\right\} \quad \dots \quad \text{(xi)}$$

$$\text{On } \mathfrak{X}_{m+1}\ \dots\dots \left\{\begin{array}{l}\{z_k(\alpha_k+\gamma_k)+y_k\alpha_k\}\{P_t-P_{t+1}\}\\ +\{z_k\gamma_k-y_k\beta_k\}\,P_{t+1}\end{array}\right\} \quad \dots \quad \text{(xii)}$$

49. *The Equations in* $\mathfrak{Y}$ *and* $\mathfrak{X}$.—A. Putting $E_{\mathfrak{Y}}$ for the error of closure in $\mathfrak{Y}_{m+1}$ at the final station, [ix] for the effects on $\mathfrak{Y}_{m+1}$ due to changes in the angles of triangles which have no side in the line of traverse (*i.e.*, for the sum of the effects represented by (ix)), and [xi] for the sum of the effects represented by (xi), the equation in $\mathfrak{Y}$ is

$$-\{[yz]_1 P_1+\dots\dots+[yz]_m P_m\}+[\text{ix}]+[\text{xi}]=E_{\mathfrak{Y}} \quad \dots \quad \text{(xiii)}$$

B. Putting $E_{\mathfrak{X}}$ for the error of closure in $\mathfrak{X}_{n+1}$ at the final station, [x] for the sum of the effects represented by ($\ddot{x}$), [xii] for the sum of the effects represented by (xii), the equation in $\mathfrak{X}$ is

$$\{[yz]_1 Q_1 + \ldots . + [yz]_n Q_n\} + [\ddot{x}] + [xii] = E_{\mathfrak{X}} \quad . \quad . \quad . \qquad \text{(xiv)}$$

50. *The Values of the Coefficients of y and z.*—A. In order to find the coefficients of the y's and z's in any, the k^{th}, triangle we may proceed thus :—

Coefficients of y and z in the $\mathfrak{Y}$ equation (Z being opposite the base and Y opposite the line of continuation), when the triangle k has no side in the line of traverse but only an angle at the station t—

Coefficient of y_k.		Coefficient of z_k.	
$+ P_t \ldots (x \text{ being } = -y - z)$. . .	from (vii)	$+ P_t (x \text{ being } = -y - z)$. . .	from (vii)
$- B_k Q_t$	„ (ix)	$+ \gamma_k Q_t$	, (ix)
Coefficient of $y_k = + P_t - B_k Q_t$		Coefficient of $z_k = + P_t + \gamma_k Q_t$	

When the triangle k has a side in the line of traverse between the stations t and $t+1$—

Coefficient of y_k.		Coefficient of z_k.	
$- P_t$	from (viii)	$- P_{t+1}$	from (viii)
$+ \alpha_k (Q_t - Q_{t+1})$ $- \beta_k Q_{t+1}$	„ (xi)	$(\alpha_k + \gamma_k)(Q_t - Q_{t+1})$ $+ \gamma_k Q_{t+1}$	„ (xi)
Coeff. of $y_k = - P_t + \alpha_k (Q_t - Q_{t+1}) - \beta_k Q_{t+1}$		Coeff. of $z_k = - P_{t+1} + \alpha_k (Q_t - Q_{t+1}) + \gamma_k Q_t$	

The values of the coefficients of the y's and z's in the $\mathfrak{X}$ equation may be found in the same way. When Y is opposite the base and Z opposite the line of continuation, the coefficients may be found from the above by interchanging y and z, and β and γ. The general rules for the symbolical expression of the values of the coefficients, are these.

B. When Z is opposite the base and Y opposite the line of continuation.
If the k^{th} triangle has a side in the line of traverse between the stations t and $t+1$—

In the $\mathfrak{Y}$ equation.	In the $\mathfrak{X}$ equation.
Coeff. of $y_k = - P_t - (Q_{t+1} - Q_t)\alpha_k - Q_{t+1}\beta_k$	Coeff. of $y_k = Q_t - (P_{t+1} - P_t)\alpha_k - P_{t+1}\beta_k$
Coeff. of $z_k = - P_{t+1} - (Q_{t+1} - Q_t)\alpha_k + Q_t\gamma_k$	Coeff. of $z_k = Q_{t+1} - (P_{t+1} - P_t)\alpha_k + P_t\gamma_k$

If the k^{th} triangle has no side in the line of traverse but only an angle X at the station t—

In the $\mathfrak{Y}$ equation.	In the $\mathfrak{X}$ equation.
Coefficient of $y_k = P_t - Q_t\beta_k$	Coefficient of $y_k = - Q_t - P_t\beta_k$
Coefficient of $z_k = P_t + Q_t\gamma_k$	Coefficient of $z_k = - Q_t + P_t\gamma_k$

C. When Y is opposite the base and Z is opposite the line of continuation.

If the k^{th} triangle has a side in the line of traverse between the stations t and $t+1$—

In the $\mathfrak{Y}$ equation.	In the $\mathfrak{X}$ equation.
Coeff. of $y_k = -\mathrm{P}_{t+1} - (\mathrm{Q}_{t+1} - \mathrm{Q}_t)\,\alpha_k + \mathrm{Q}_t\beta_k$	Coeff. of $y_k = \mathrm{Q}_{t+1} - (\mathrm{P}_{t+1} - \mathrm{P}_t)\,\alpha_k + \mathrm{P}_t\beta_k$
Coeff. of $z_k = -\mathrm{P}_t - (\mathrm{Q}_{t+1} - \mathrm{Q}_t)\,\alpha_k - \mathrm{Q}_{t+1}\gamma_k$	Coeff. of $z_k = \mathrm{Q}_t - (\mathrm{P}_{t+1} - \mathrm{P}_t)\,\alpha_k - \mathrm{P}_{t+1}\gamma_k$

If the k^{th} triangle has no side in the line of traverse but only an angle X at the station t—

In the $\mathfrak{Y}$ equation.	In the $\mathfrak{X}$ equation.
Coefficient of $y_k = \mathrm{P}_t + \mathrm{Q}_t\beta_k$	Coefficient of $y_k = -\mathrm{Q}_t + \mathrm{P}_t\beta_k$
Coefficient of $z_k = \mathrm{P}_t - \mathrm{Q}_t\gamma_k$	Coefficient of $z_k = -\mathrm{Q}_t - \mathrm{P}_t\gamma_k$

D. Should X be opposite the base or opposite the line of continuation, the coefficients may be either specially investigated, or derived from the general rules by cyclical interchange of symbols and substitution of $-(y+z)$ for x.

E. In the adjustment of the circuits of this survey the *corrections* to the angles were equated to the corrections for closure; the signs of the coefficients are therefore opposite to those given by the above rules.

51. The base equations, and the equations in $\mathfrak{Y}$, $\mathfrak{X}$, and bearing for each circuit, having been formed in the manner described, the normal equations are formed and solved, and the corrections to the angles obtained in the usual way.

52. It is not essential that the origin of co-ordinates should be the same for all circuits, because the conditions of the circuits have to be satisfied simultaneously whatever the origins may be; nor is it desirable (in an extensive survey) for the reason that the $\mathfrak{Y}$'s should be kept as small as possible. The ideal position of the origin of a circuit is the centre of the circuit. In the adjustment of this Survey two origins were chosen, one on the 26th and the other on the 29th meridian, and both on the 25th parallel—the difficulty of dealing with large $\mathfrak{X}$'s being overcome by the expedient described in paragraph 39D. As in no case was any station so much as 3° in $\mathfrak{Y}$ from its origin, the Formulæ III and VI are sufficiently accurate for this adjustment; they may, however, be developed to any required degree of accuracy, but, beyond certain limits of $\mathfrak{Y}$ this method of adjustment becomes too laborious. Approximations (sufficiently close to give a sensibly correct value of the small terms in Formulæ III and VI) to the position of the initial station and to the bearing of the initial line, are all that are necessary.

53. Formula for computing the star correction for the mean of a pair of latitude stars:—

a. It is understood that the following formula for the star correction in declination to the mean of a pair of stars (observed for latitude by Talcott's method) was first given in one of the reports of the U.S. Coast and Geodetic Survey. As, however, this work was not available for reference, the formula was re-investigated for this survey.

b. Let δ_1 denote the mean declination and α_1 the mean R.A. (in arc) of the 1st star, and let δ_2 denote the mean declination and α_2 the mean R.A. (in arc) of the 2nd star.

Using the Nautical Almanac Formula and "Quantities for Correcting the Places of Stars," we have

$$\text{App Dec. of 1st star} = \delta_1 + i\,.\cos\delta_1 + g\,.\cos(\mathrm{G}+\alpha_1) + h\,.\cos(\mathrm{H}+\alpha_1)\sin\delta_1,$$
$$\text{App. Dec. of 2nd star} = \delta_2 + i\,.\cos\delta_2 + g\,.\cos(\mathrm{G}+\alpha_2) + h\,.\cos(\mathrm{H}+\alpha_2)\sin\delta_2.$$

Put ϕ for the latitude of the place of observation,

$$\phi + x \text{ for } \tfrac{1}{2}(\delta_1 + \delta_2),$$
$$z \text{ for } \tfrac{1}{2}(\delta_1 - \delta_2),$$
$$\alpha_0 \text{ for } \tfrac{1}{2}(\alpha_1 + \alpha_2),$$
$$y \text{ for } \alpha_0 - \alpha_1 = \alpha_2 - \alpha_0,$$

then the mean apparent declination of the pair is

$$\tfrac{1}{2}(\delta_1 + \delta_2) + i \,.\, \cos\phi \,.\, \cos z + g \,.\, \cos(G + \alpha_0)\cos y$$
$$+ h \,.\, \cos(H + \alpha_0)\sin\phi \,.\, \cos z \,.\, \cos y + h \,.\, \sin(H + \alpha_0)\cos\phi \,.\, \sin z \,.\, \sin y$$
$$+ 3 \text{ small terms.}$$

The 3 small terms are

$$- i \,.\, \sin\phi \,.\, \cos z \,.\, \sin x \quad . \quad . \quad . \quad . \quad (\text{A})$$
$$+ h \,.\, \cos(H + \alpha_0)\cos z \,.\, \cos y \,.\, \cos\phi \,.\, \sin x \quad . \quad . \quad . \quad . \quad (\text{B})$$
$$- h \,.\, \sin(H + \alpha_0)\sin z \,.\, \sin y \,.\, \sin\phi \,.\, \sin x \quad . \quad . \quad . \quad . \quad (\text{C})$$

The maximum values of the neglected terms (for the limits of latitude of the Transvaal and Orange River Colonies) are less than 0·″010, 0·″040 and 0·″005 respectively.

If y is small and expressed in minutes of arc we may put

$$\cos y = 1, \qquad \sin y = y \,.\, \sin 1',$$

then the formula for the mean star correction is

$$i \,.\, \cos\phi \,.\, \cos z + g \,.\, \cos(G + \alpha_0) + h \,.\, \cos(H + \alpha_0)\sin\phi \,.\, \cos z$$
$$+ h \,.\, \sin(H + \alpha_0)\cos\phi \,.\, \sin z \,.\, y \,.\, \sin 1'.$$

Putting k for $\cot\phi \,.\, \tan z_1$ this becomes

$$i \,.\, \cos\phi \,.\, \cos z + g \,.\, \cos(G + \alpha_0) + h \,.\, \cos\{H + (\alpha_0 - k \,.\, y)\}\sin\phi \,.\, \cos\phi.$$

W. B. ROBINSON.

APPENDIX TO MR. W. B. ROBINSON'S REPORT.

DISCUSSION OF THE GEODETIC POSITION OF MR. MELVILL'S ASTRONOMICAL STATION AT JOHANNESBURG, AND THE CONNECTION BETWEEN THE RAND SYSTEM OF SURVEYS AND THE GEODETIC SYSTEM.

In 1892, Mr. E. H. V. Melvill determined the astronomical latitude and longitude of one of his stations in the Goldfields Survey. This station was on stand No. 17, Noord Street, upon which are now some offices of the C.S.A. Railway.

The instrument employed was a 10-inch Repsold of the type described in Vol. I. of "The Geodetic Survey of South Africa." Latitude was determined by the Talcott method, 46 observations being made of 15 pairs of stars. Longitude was determined by the telegraphic method, signals being exchanged with the Royal Observatory, Cape of Good Hope, and the personal equation of the observers subsequently determined.

The astronomical station was connected by triangulation with the principal stations of the Goldfields (or Rand) Survey.

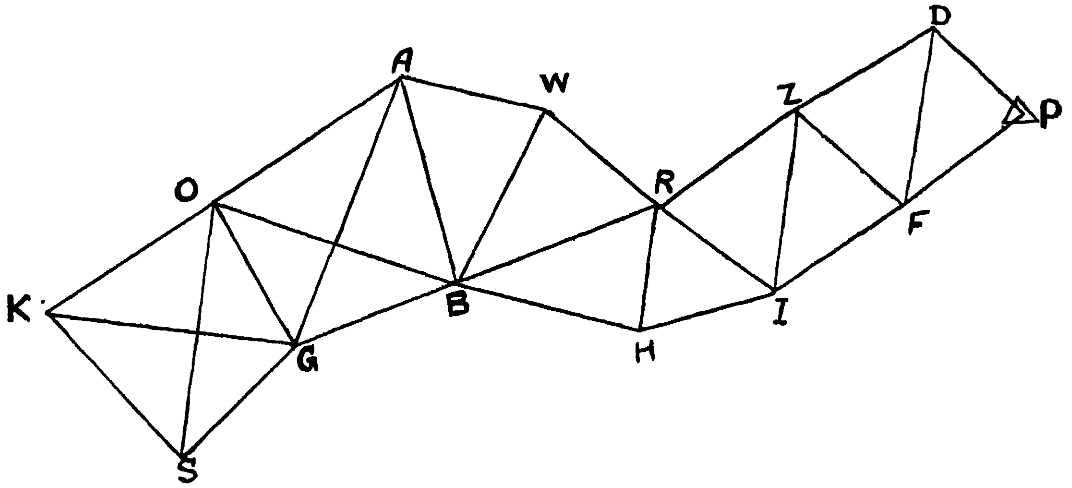
After the completion of the primary triangulation of the Transvaal and Orange River Colony, a secondary triangulation was made between two of the stations of the geodetic circuit and two of the stations of the Rand Survey. The observer was Captain H. W. Gordon, R.E., and the instrument a 6-inch transit theodolite, fitted with micrometers, by Troughton and Simms. One of the geodetic stations (Observatory Hill) is also an astronomical station, where astronomical latitude and azimuth were determined in 1904 by the Superintendent of the Trigonometrical Survey.

This triangulation and the triangles of the Rand system made a complete connection between the Geodetic system and Mr. Melvill's station, and thus, incidentally, the whole of the Rand system.

LIST OF DATA.

Following the diagram of triangulation and names of stations, the data are given in this order:—

1. The geodetic latitudes, longitudes, and mutual azimuths of the two stations in the geodetic circuit, together with the logarithm of the distance between them in English feet.
2. Captain Gordon's observed angles in each triangle, and, for convenience of reference, the seconds of the finally corrected angles.
3. The co-ordinates of stations on the Rand system, used in the connection but not occupied by Captain Gordon.
4. Observed vertical angles. Height above mean sea-level of geodetic station.
5. Height of bench mark on old Pretoria bridge, Johannesburg. Differences of height between bridge and the base of the Rand system.



Names of Stations.

P ... Cable Hill, Pretoria
O ... Observatory Hill, Johannesburg } Stations fixed in the geodetic circuit.
D ... Daspoort.
F ... Klapper Kop.
Z ... Zwartkop.
I ... Irene.
R ... Brakfontein.
H ... Olifantsfontein.
W ... Witkop.
B ... Klipfontein.
A ... Driefontein.
G ... Germiston.
S ... P_6 or K of Rand system.
K ... Klipriviersberg = P_4 of Rand system.

DATA.

1. THE GEOGRAPHICAL CO-ORDINATES OF THE FIXED STATIONS— CABLE HILL AND OBSERVATORY HILL.

Cable Hill.

Latitude ... 25° 41′ 27·326″ Longitude ... 28° 10′ 8·050″
Azimuth of Observatory Hill ... 9° 33′ 34·55″

Observatory Hill.

Latitude ... 26° 11 1·575″ Longitude ... 28° 4′ 36·899″
Azimuth of Cable Hill ... 189° 35′ 59·39″

The logarithm of distance (English feet) Cable Hill—Observatory Hill is 5·2592622.

2. OBSERVED ANGLES.

△ PDF.	°	′	″	Secs. of corrected angle. ″
P ...	81	9	22·88	23·34
D ...	57	5	38·41	38·89
F ...	41	44	57·52	58·00

△ DZF.	°	′	″	Secs. of corrected angle. ″
D ...	46	59	24·15	24·10
Z ...	75	15	51·16	51·13
F ...	57	44	45·06	45·03

△ FZI.				
F ...	75	28	22·12	22·96
Z ...	56	1	18·72	19·57
I ...	48	30	16·86	17·71

△ ZIR.				
Z ...	47	24	34·80	34·02
I ...	61	0	47·81	47·04
R ...	71	34	39·97	39·20

△ IHR.				
I ...	52	46	43·31	42·96
H ...	63	11	11·20	10·84
R ...	64	2	6·74	6·38

△ HRB.				
H ...	85	53	59·46	58·90
R ...	59	37	15·82	15·25
B ...	34	28	46·70	46·13

△ RWB.				
R ...	62	25	5·61	5·02
W ...	75	5	43·22	42·64
B ...	42	29	13·27	12·69

△ WAB.				
W ...	71	31	4·30	4·67
A ...	65	47	0·46	0·83
B ...	42	41	54·47	54·84

△ AOB.				
A ...	71	20	38·03	38·75
O ...	51	51	51·32	51·43
B ...	56	47	30·16	30·34

△ GOB.				
G ...	99	29	15·30	15·88
O ...	56	54	25·78	26·33
B ...	23	36	18·37	18·04

2. OBSERVED ANGLES—*continued.*

△ GAB.	°	′	″	Secs. of corrected angles. ″
G ...	49	1	30·08	30·43
A ...	50	34	41·84	41·71
B ...	80	23	48·53	48·32

△ GOA.	°	′	″	Secs. of corrected angles. ″
G ...	50	27	45·22	45·45
O ...	108	46	17·10	17·76
A ...	20	45	56·19	57·04

△ KOG.	°	′	″	″
K ...	36	22	1·48	2·99
O ...	89	16	25·74	26·90
G ...	54	21	30·62	30·28

△ SKG.	°	′	″	″
S ...	95	57	46·83	46·39
K ...	33	42	20 93	21·59
G ...	50	19	53·27	52·17

△ SKO.	°	′	″	″
S ...	56	57	39·53	40·23
K ...	70	4	22·41	24·58
O ...	52	57	53·94	55·40

△ SOG.	°	′	″	″
S ...	39	0	7·30	6·16
O ...	36	18	31·80	31·50
G ...	104	41	23·89	22·45

3. CO-ORDINATES OF STATIONS ON RAND SYSTEM.

Cape Roods.

	Y	X.
P_1	0·00	0·00
P_2	− 137·44	− 767·38
K = P_4	− 1448·01	− 522·90
S = P_6	− 661·10	− 2798·37
P_9	+ 980·74	− 238·73
Astronomical station ...	+ 657·362	+ 363·079

The Y axis is true north at a point 270 Cape roods west of P_1, its co-ordinates are therefore

	Y.	X.
A_0	0·00	+ 270·00

4. HEIGHT ABOVE MEAN SEA LEVEL OF OBSERVATORY HILL, AND OBSERVED VERTICAL ANGLES.

The height above mean sea level of Observatory Hill, computed through vertical angles from the mean sea level datum at Port Elizabeth, is 5930·0 English feet.

Vertical Angles.

Observed by Captain Gordon.

At O.	°	′	″
G ...	− 0	12	15
K ...	− 0	0	47·5
S ...	− 0	48	55

At K.	°	′	″
O ...	− 0	8	2·5
G ...	− 0	9	52·5
S ...	− 0	51	52·5

At G.	°	′	″
O ...	+ 0	10	0
K ...	+ 0	5	7·5
S ...	− 0	57	45

At S.	°	′	″
O ...	+ 0	39	35
G ...	+ 0	55	20
K ...	+ 0	48	47·5

Observed by Mr. Melvill.

At K.	°	′	″
S ...	− 0	52	29
P_1 ...	− 1	0	20
P_9 ...	− 0	3	20

At P_1.	°	′	″
K ...	+ 0	57	35
P_2 ...	− 0	49	52
P_9 ...	+ 1	26	2

At S.	°	′	″
K ...	+ 0	48	22
P_9 ...	+ 0	36	10

At P_2.	°	′	″
P_1 ...	+ 0	47	22
P_9 ...	+ 1	40	9

5. HEIGHT OF BENCH MARK AND DIFFERENCES OF HEIGHT BETWEEN BENCH MARK AND BASE OF THE RAND SYSTEM.

The height of the bench mark on the old Pretoria bridge in Johannesburg is 5700·0 English feet above mean sea level by geodetic levelling from the mean sea level datum at Delagoa Bay. The road level of the bridge is 15 feet higher.

From the Municipal Contour plan

P_1 is 96 English feet below roadway.
P_2 is 233 „ „ „

The data, other than those furnished by Captain Gordon's observations, were supplied by Mr. E. H. V. Melvill and Mr. W. C. van der Sterr.

RESULTS OF TRIANGULATION.

In order to obtain an approximation to the lengths and bearings of the lines, the figure was first treated as a plane and the plane co-ordinates of all points computed with an assumed length and direction for the initial line PD, the angles being simply corrected to sum to 180° in each triangle.

The ratio of the length of the line OP, obtained from these co-ordinates, to its known length sufficed for the computation of the spherical excesses of the triangles.

The quadrilaterals were then adjusted by the method of Least squares, and the spheroidal (Cassini-Soldner) co-ordinates of all points computed; the intersection of the 28th meridian and 26th parallel being taken as origin.

The result of this computation was sufficiently close to permit of the final co-ordinates being computed differentially.

The angles necessary to continue the computation to other stations on the Rand Survey were derived from their co-ordinates on the Rand System (Data 3).

The following are the final results for all stations considered in the discussion:—

Spheroidal Co-ordinates.

Origin: Latitude + 26°, Longitude — 28°.
+ Latitude = South, + Longitude = West.
+ X = South, + Y = West.

	Y.	X.	
	English feet.	English feet.	
Cable Hill	— 55625·9	— 112298·5	Fixed in the Geodetic Triangulation.
Observatory Hill ...	— 25226·2	+ 66801·4	
Daspoort	— 31962·5	— 97884·3	
Klapper Kop	— 68997·1	— 80023·1	
Zwartkop	— 42632·2	— 63549·4	
Irene	— 79330·7	— 47191·9	
Brakfontein	— 54427·4	— 28433·3	
Olifantsfontein ...	— 79203·4	— 15784·2	
Witkop	— 25037·2	— 10833·1	
Klipfontein	— 57277·0	+ 20497·2	
Driefontein	— 10542·0	+ 19288·3	
Germiston	— 48080·1	+ 67438·8	
S	— 52952·6	+ 88390·8	
K	— 24749·5	+ 98132·0	
P_1	— 18276·2	+ 80184·7	
P_2	— 27785·5	+ 81891·6	
Astronomical Station ...	— 13779·7	+ 72036·4	
„ Origin ...	— 14930·1	+ 80183·4	

COMPARISON OF GEODETIC AND ASTRONOMICAL RESULTS.

At Observatory Hill.

	°	′	″
Geodetic Latitude.. ..	26	11	1·575
Astronomical Latitude ..	26	10	52·15
G − A			+ 9″·42

	°	′	″
Geodetic Azimuth of Cable Hill	189	35	59·39
Astronomical Azimuth of Cable Hill	0	0	59·68
G − A			− 0″·29

At Mr. Melvill's Astronomical Station.

Transforming the Spheroidal Co-ordinates into latitude and longitude, we get—

	°	′	″
Geodetic Latitude.. ..	26	11	53·477
Astronomical Latitude ..	26	11	44·19
G − A			+ 9″·29

	°	′	″
Geodetic Longitude ..	− 28	2	31·27
Astronomical Longitude	− 28	2	30·3
G − A			− 0″·97

At the Astronomical Origin of the Rand System.

At the Astronomical Origin, Bearings + 90° = Azimuths (in Rand system)—

		°	′	″
From Geodetic Co-ordinates, Geodetic Azimuth of S	=	282	9	38·04
„ Rand Co-ordinates, Astronomical Azimuth of S	=	282	9	31·95
G − A				+ 6″·0

RELATION OF RAND SYSTEM TO GEODETIC SYSTEM.

The Base of the Rand System.

From the co-ordinates of P_1 and P_2 on the Rand system (Data 3), the measured length of the base is

779·5908 Cape roods = 9663·808 English feet.

For the height above mean sea level we have—Height of Observatory Hill, and vertical angles between O and the terminals of the base (Data 4), and height of bench mark and differences of height between B.M. and the terminals of the base (Data 5).

The vertical angles give the following differences of height:—

Captain Gordon.

	English feet.
G − O... ...	− 74·0
K − O... ...	+ 10·3
S − O... ...	− 426·8
K − G... ...	+ 84·1
S − G... ...	− 353·8
S − K... ...	− 436·9

Mr. Melvill.

	English feet.
S − K... ...	− 437·7
P_1 − K... ...	− 327·3
P_9 − K... ...	− 11·0
P_9 − S	+ 427·2
P_1 − P_9 ...	− 317·1
P_2 − P_9 ...	− 452·8
P_2 − P_1 ...	− 136·7

Combining these results, we get, from vertical angles—

P_1	5,613 English feet above M.S.L.
P_2	5,476 „ „ „ „

Data 5 give—

P_1	5,619 English feet above M.S.L.
P_2	5,482 „ „ „ „

For the purpose of reducing to mean sea level, the mean height of the Rand base may be taken = 5,545 English feet.

For this height, in latitude 26° 13′, the *correction to reduce* to *mean sea level* is — 2·566 English feet.

The measured length reduced to mean sea level is, therefore, 9,661·242 English feet.*

The length computed from the geodetic line is 9,661·296 English feet.

Thus the discordance between measured and computed lengths is only 0·054 English feet, or, 1 in 179,000.

The Orientation of the Rand System.

From the co-ordinates of S on the Rand system, the bearing of S at the origin P_1 is 193° 17′ 31″63.

From the spheroidal co-ordinates of P_1 and S (origin latitude 26, longitude — 28)—

		°	′	″
Bearing of S at P_1...		283	18	50·12
and $\alpha - \beta$ (Azimuth — Bearing) ...	—	0	1	28·66
∴	$\alpha =$	283	17	21·46

Thus (remembering that the systems differ 90° in azimuth) the error of orientation of the Rand system is + 10″·17.

Owing to the spherical excess being neglected, a small difference in the result will be obtained if the bearing of another station be compared with its geodetic azimuth.

TRANSFORMATION OF RAND CO-ORDINATES INTO GEOGRAPHICAL CO-ORDINATES ON THE GEODETIC SYSTEM.

The transformation of Rand co-ordinates into geodetic latitudes and longitudes can readily be effected.

Put—

Y_q, X_q for the co-ordinates, on the Rand system, of station q.

(Y_q), (X_q) for the co-ordinates of q corrected for errors of base and orientation.

S for the distance of q from the origin (Cape roods).

B for the bearing of q from the origin.

d log S for the correction to the logarithm of S to reduce to mean sea level and the geodetic system.

d B for the correction to the bearing for error of orientation.

ϕ_o for the latitude, and L_o for the longitude of the origin.

ϕ_q for the latitude, and L_q for the longitude of q.

R_m for the radius of curvature of the meridian for mid-latitude $\frac{1}{2}(\phi_o + \phi_q)$.

R_n for the radius of curvature of the perpendicular arc from q on the meridian of the origin.

μ for the modulus of the common system of logarithms.

$$M = \frac{1}{R_m \,.\, \sin 1''}, \quad N = \frac{1}{R_n \,.\, \sin 1''}, \quad E = \frac{1}{2R_m R_n \sin 1''} \,.\, \tan \phi_q.$$

---

* This is the length derived from the co-ordinates (given to the second place of decimals of a Cape rood only). Mr. Van der Sterr supplies the following note:—

> "Mr. Melvill used in his calculations for the log: distance P_1P_2 2·8918678; this reduced to English feet and mean sea level gives 9661·267 English feet, differing 1 in 383,000."

1 Cape rood = 12·396 English feet.

Then the following formulæ are sufficiently accurate for all stations on the Rand Survey:—

$$(Y_q) = Y_q + X_q \,.\, dB \,.\, \sin 1'' + \frac{d \log S}{\mu} \,.\, Y_q ;$$

$$(X_q) = X_q - Y_q \,.\, dB \,.\, \sin 1'' + \frac{d \log S}{\mu} \,.\, X_q ;$$

and

$$\phi_q = \phi_o - (Y_q) \,.\, M - (X_q)^2 \,.\, E ;$$

$$L_q = L_o + (X_q) \,.\, N \,.\, \sec \phi_q .$$

$\phi_o = 26^\circ\ 13'\ 14''\cdot165.$ $L_o = -\ 28^\circ\ 3'\ 20''\cdot674.$

$dB = -\ 10''$ $d \log S = -\ 0\cdot0001130.$

$\therefore\ dB \,.\, \sin 1'' = -\ 0\cdot0000485$ and $\frac{d \log S}{\mu} = -\ 0\cdot000260.$

The logarithms of M, N, and E may be tabulated for argument Y.

TABLE OF LOGARITHMS OF CONSTANTS DEPENDING ON LATITUDE.

(Clarke's Elements.)

Argument Y.

Y.	Log M.	Log N.	Log E.
+ 4,000	9·0891196	9·0867305	2·2502
+ 3,000	1186	7298	09
+ 2,000	1176	7292	15
+ 1,000	1165	7284	22
0	1155	7277	28
− 1,000	1144	7272	34
− 2,000	1134	7265	41
− 3,000	1124	7257	47
− 4,000	9·0891114	9·0867249	2·2554

Example.

Given the co-ordinates of O (Observatory Hill) on Rand system

Y ... ... + 1080·14, X ... ... − 560·41,

to find the latitude and longitude of O.

Y	+ 1080·14	X	− 560·41
$X \, . \, dB \, . \sin 1''$	+ 0·027	$- Y \, . \, dB \, . \sin 1''$	+ 0·052
$Y \, . \, \frac{d \log S}{\mu}$ ...	− 0·281	$X \, . \, \frac{d \log S}{\mu}$ ...	+ 0·146
(Y) ...	+ 1079·89	(X) ...	− 560·21

log (Y) ...	3·0333795	log $(X)^2$ ...	5·4967	log (X) ...	2·7483509 *n*
„ M ...	9·0891166	„ E ...	2·2521	„ N ...	9·0867284
				L sec ϕ_0 ...	0·0470220
	2·1224961		7·7488		1·8821013 *n*
	132·5857		0·0056		− 76″·226

	°	′	″		°	′	″
ϕ_0 ...	26	13	14·165	L_0	− 28	3	20·674
	− 0	2	12·591		− 0	1	16·226
Lat. of O ...	26	11	1·574	Long of O ..	− 28	4	36·900

REPORT BY MR. A. SIMMS ON THE MEASUREMENT OF BASELINES.

Introductory.

1. The earlier development of the subject of base measuring by means of wires is fully treated of by Herr Eduard Jaderin in his "Method of Measuring Geodetic Bases by Means of Metallic Wires," to the English translation of which (by the Survey of India Department) one may readily refer.

2. Jaderin shows the reasons for his adoption of a measuring wire of about 25 metres in length and of 1·6 mm. in diameter, suspended under a strain of 10 kilogrammes. He discusses the whole theory of the catenary of such a wire, and treats of the expansions of a steel measuring wire, and of the method of gauging its temperature in the field by using an auxiliary brass measuring wire in conjunction with it.

He further describes his method of rapidly and reliably measuring the differences in height between the extremities of the wire intervals, treats of the resulting linear corrections, and gives a complete account of his mode of conducting a base-measure, and of the manner in which he compared the measuring wire with the Bar Standard. He discusses the faults of the measuring wires then in use (1882), and adds the results of some extensive wire-measures conducted by himself personally.

3. Since the publication of the pamphlet under reference, very great improvement has been made in the manufacture of the wires, and the inconstancy of wire-length of which Jaderin complains, has been almost eliminated by a superior system of annealing and treatment. Further, the use of a measuring wire of steel gave place to one of nickel-steel with a much smaller coefficient of expansion, and that in its turn to a wire of an alloy which has an expansion so small as to be insensible throughout any natural range of air-temperature, and which can, therefore, be used singly in the field, thus simplifying at once all the operations of comparison, measure, and reduction.

4. Our experience with the Jaderin apparatus in the Transvaal and Orange River Colony covers the work of measurement of *five* different bases, measuring in their sum almost *seventy miles*. We have thus been able to get a relatively extensive knowledge of the merits of the system, and of the most effective and economical manner of conducting the field measures.

Field Equipment.

5. The field equipment consisted of:—

(*a*) Ten tripods, similar to those described by Jaderin, each carrying a vertical cylinder, having a pair of index lines at right angles to one another engraved on its upper face, and adjustable by movement of two ball-and-socket joints below. These joints are clamped by a contained screw-key.

(*b*) A rough steel wire, of approximately the same length as the measuring wire, employed under a constant tension to set the tripods at distances suitable for measurement.

(*c*) Sets of measuring wires of nickel-steel (having a sensible co-efficient of expansion) brass, and "invar." The measuring wires were suspended under a strain of ten kilogrammes applied by means of—

(*d*) Metallic weights attached to the ends of the wire by cords which passed over—

(*e*) Free pulleys running in open brass brackets which formed the middles of long light wooden poles. The poles were held by assistants so as to bring the wire-scale rapidly to its proper position of contact with the cross-line of the tripod cylinder-head.

The aligning instrument supplied with the apparatus was not used. Instead, it was found convenient to work with—

(*f*) Two small transit theodolites, each stripped of its vertical circle and appendages. The most portable and reliable instrument for this work is a good four-inch transit, stripped as described, and fitted with a long direct-image eyepiece of a power about 15. In the absence of the vertical clamp, the telescope may be easily counterpoised by attaching a small weight on the eyepiece, so that small vertical movements are easily communicated without the aid of "slow motions".

With two such instruments, the alignment of the tripods can be effected at great speed, each observer in turn directing the alignment of the tripods up to his instrument. In favourable country he may be able to give the line to the tripod-setter during the placement of 10 or 14 tripods, without shifting his instrument.

The measures of the differences of height between successive tripod-tops were made with—

(*g*) A 12-inch Dumpy Level. The stability and superior optical power of this instrument were found to give it an advantage over the small levelling apparatus supplied with the Jaderin equipment, which more than compensated for the increased difficulty of local adjustment.

It was moreover found convenient to replace the Jaderin levelling-staff by—

(*h*) A staff of a length of 4 metres. This staff was divided as Jaderin suggests, so that on one side the black unit was a decimetre, and on the other the red unit was one-seventh of a metre. The staff was provided with an attached circular level, and was constructed so as to close to a length of 2·2 metres for use over comparatively level ground.

Base Measuring Apparatus.

6. The Base Measuring Apparatus employed for measuring the "Ground-Standards," with which the measuring wires were compared, is fully described in "The Report of the Geodetic Survey, South Africa," Vol. I. (1894). It consisted of—

1. Five ten-foot steel bars, each with three embedded thermometers, and mounted in a light mahogany case.
2. Ten camels or brass tripods carrying the bar-rollers with position adjustments.
3. Twelve wooden tripod stands, on the tables of which the camels were placed.
4. Twelve wooden triangles, designed, by placement on the ground picket, to give an extensive level surface over which to adjust the position of the standing wooden tripods.
5. Two vertical transferring rods, with attached levels.
6. Two stands for the rods, designed to adjust and hold the rod over a terminal ground-point.
7. Two bases for the rod-stands, by which the vertical rod can be moved horizontally to serve as the standing index of the terminal point of an unfinished bar-measure.
8. Ten light portable wood-and-canvas huts under which the Standard-Bar measures were conducted.
9. A micrometer microscope for the measurement of small linear increments about the end of a bar.

Measuring the base: division of the work.

7. The work of base-measurement consisted essentially in two operations, viz., the direct measure of the baseline in terms of the wire-lengths, and the periodic determination of the lengths of the measuring wires in terms of the bars.

With respect to the second operation, the secular change in length of a modern Jaderin wire is so small that it is sufficient to standardise the wire immediately before and immediately after one complete measure of the base-line proper.

Base-measuring party.

8. The Staff of the base-measuring party, was composed as follows :—

Two aligners, each with his instrument.

One European and one native to extend the rough or setting wire, and one European to place the tripods against the wire-end and adjust them in line by the direction of the aligner. Two natives, who supported the pulley-rods of the measuring wire, accompanied by two other natives who released or supported the extending weights of the wire according to the directions of the measurers.

Two Europeans, of whom the hinder one controlled the zero of the wire-scale, and the forward one who observed and recorded the resulting reading of the forward wire-scale.

One European, who conducted and recorded the levelling operations, assisted by a native staff-holder.

About five natives who carried forward the tripods as fast as they were released by the levelling party behind.

There were thus engaged in the measures seven Europeans and about eleven natives.

Terminal piers.

9. After the selection of the baseline site, the measuring party had first to put in the terminal piers of the line. These were of concrete and in dimensions about 2½ feet square by 3 or 4 feet deep. The top face contains an embedded brass pyramid in which is a small drill-hole indicating the terminal point. After the completion of the measures, the block receives a fitting concrete cap, which preserves the pier-face from injury and is at the same time removable. The whole is usually covered with earth, and its approximate position is marked by an adjacent stone-pile.

Sectional points.

10. The intermediate sectional points of the base are then marked with flag-stones at intervals of two or three miles, and following this the line of measure is further defined by short rods driven into the ground at intervals of about 300 yards. These project about a foot above the ground surface, and are subsequently occupied by the tripod aligners.

Alignment.

11. In measurement it was found convenient for the aligner to occupy a forward point, and after having directed the alignment of the tripods almost up to himself, to remove his instrument and so expose the second aligner already forward and in position to continue the work.

If some such plan of working is not adopted, the process of alignment is sometimes liable to cause delay in the measurement.

The man who places the tripods on the line is provided with a vane attachable to the tripod cylinder, so that at considerable distances the aligner may easily see the line of the cylinder under adjustment.

Setting the intervals.

12. Of the two men who extend the setting wire, the European was placed behind so that he could set the index line of the wire against the cylinder of the last tripod and could rapidly direct the native to bring his forward end of the wire into approximate line. The final line-adjustment is then effected by means of the ball-and-socket joints of the tripod head. In case any considerable adjustment has been made, it is as well to try the length again before going forward.

Measuring the intervals.

13. On arrival in position before the tripods, the two Europeans of the measuring party are carrying the wire, while the pole-holders are assisted by the weight carriers. The pole-holders immediately place their poles in position on the line, and each extends the hook of his weight-cord to the European, who attaches the hook to the wire-ring, and they mutually call "Right," whereupon the weight-holders quickly but gently release the weights in position under the pulleys. The pole-holders then direct their poles so that the wire-scales come quickly and steadily into position over the cylinder indices, and on the back reader getting his zero steady in position and calling "Now," the forward reader takes a deliberate reading, books its, grasps the wire-ring and calls "Right," when, on the weight-holders lifting the weights, the wire is detached simultaneously at each end, and the party proceeds forward to the next interval. With intelligent and alert assistants, mechanical regularity is very soon gained in this operation. The readers should assure themselves that the pulleys of the poles are perfectly free from any restraint and that they are playing truly on the line of measure. It is a good plan for the measurers to reverse the wire, end for end, at intervals of about 30 wire-lengths, so as to vary the illumination of the scales, and further to secure the condition that in any section there shall be an approximately equal number of scale records read from right to left and from left to right

Differences of height of tripod-tops.

14. The leveller, who follows the measuring party, preserves his instrument over one aligning pin for as great a length of time as the gradient of the ground and the length of his staff allow him to read the staff-divisions distinctly. He commonly takes up a position about equidistant from the extremities of the section under measurement. Before passing forward he

assures himself by a comparison of the differences of his red and black staff-readings that his records are within the limits of observation-error.

Rate of progress.

15. It is desirable, for the rapid and undisturbed progress of a measuring party, that the components shall be so balanced that neither shall habitually delay the others. We have found the composition and methods here described to overcome all the original liability to disturbance. With a party of this kind, the average *daily* rate of progress would be about *five miles*.

Sub-division of baselines.

16. The baselines were commonly divided into sections, each of from one to three miles in length. The end of a section is defined by a cross-line filed on the head of an iron pin driven into the ground.

In order to avoid tape-intervals, representing fractions of a wire-length, it has been found convenient to abandon the original plan of fixing these section terminals before the measure begins, and instead to place each section-pin below the end of the last wire-length in the first measure. In subsequent measures it is not difficult to so arrange matters that the section-terminal point shall fall again under the scale of the measuring wire. There is thus only one tape measure—that at the base end. The vertical transfer of a ground point to the wire-scale, or *vice versa,* was always made with a transit theodolite, mounted close to the point and at right angles to the line, and having its axis-level attached.

Superiority of one-wire measuring.

17. After the adoption of the "invar-wire" it became unnecessary to employ two measuring wires. With two wires in use, the difference of the scale readings was assumed to furnish, besides the temperature of the wire, a guarantee of accuracy of scale reading. I am not at all sure, however, that the conformity is worth much. The most common errors of record are of sign or of tens of the unit. From former experience, it seems likely that a reader is liable with two wires to be paying greater attention to the change of temperature (as indicated by the small changes in the differences of the scale readings) than to larger matters, and if he has unconsciously recorded a wrong sign for the first scale reading he is quite likely, in a distracted mood, mechanically to repeat it for the second. With the single wire there is no technical reason for distraction, and it may be there is less liability to error, since the reader knows he is making a locally unsupported record. Of course, if he is conscious that he has ceased to be alert, he should stop work.

Sign of scale reading.

18. In order to avoid a continual liability to change in the sign of the scale reading, it has been found convenient to direct the tripod-setter to avoid setting out intervals of about the length between the zeros of the measuring wire, and instead to adopt a long series, first of longer and then of shorter intervals. The reader is thus absolved, not of course from paying constant attention to the signs of the readings, but of constantly recording changes. Further, the summation of the increments is simplified.

Computed measured length of Baseline.

19. With the single wire, the computed measured length of the Baseline is derived from the single form:

$$L = n . c + (s) + (l),$$

where n is the number of wire intervals,

c is the standard length of the wire between its zeros,

(s) is the sum of the scale readings,

(l) is the sum of the level corrections, each correction being taken from a previously prepared table computed from:

$$L = \frac{h^2}{2S} + \frac{h^4}{8S^3}$$

h being the difference in height between two tripods, and S being the wire-length. The second term is almost invariably insensible.

COMPARISON OF MEASURING WIRES WITH GROUND-STANDARDS.

Length of Ground-Standards.

20. The two Ground-Standards which were measured with the Bar-apparatus, and with which the wires were compared, were invariably of the approximate lengths of 80 feet and 480 feet. The method of wire-comparison

on the 80 feet length as described by Jaderin is the quicker and simpler method, but it has the disadvantage that it is conducted under circumstances quite dissimilar to those under which the wire is used in the field, and it therefore leaves one liable to unknown systematic error in the adopted wire-lengths. For the purpose of tracing expansions it is very convenient, since it is completely covered by the bar-huts. It is also quite suitable for a rapid comparison of wires with one another. We have, however, always preferred to determine the standard wire-length from a multiple set of wire-measures of an interval of 480 feet, which are accompanied by carefully conducted bar-measures of the line, and the preference was subsequently justified by the evidence

Site for Ground-Standards.

21. The conditions sought in the selection of the ground for these Ground-Standards were : a position about midway down the baseline, an accesible rock-bottom for the foundations of the terminal piers, and proximity to a good water supply. Since the whole of the laborious work of bar-measure and of wire-comparison was made on these standards, the main camp was naturally established close at hand

Terminal Piers.

22. The terminal piers were in dimensions about 2½ feet square and of the depth necessary to secure, if possible, a rock bottom, or otherwise the firmest foundation reasonably attainable. Of the ground-standards at the 5 base lines there are two in which the accumulated bar-measures appear to indicate some slight progressive movement in the terminal piers, and the wire-lengths have been adopted on this hypothesis.

Wooden Pickets v. Concrete.

23. The use of wooden pickets as foundations for the bar-tripods was adopted at Belfast ; but on the second baseline, that at Ottoshoop, the extremely rocky nature of the ground utterly forbade picket-driving, and we were therefore obliged to prepare, in place of the picket-heads, sets of simple surface supports, provided by letting into the ground, at a shallow depth, either flat stones or loosely made concrete. The faces of these supports were made level, and as they presented surfaces considerably larger than those of picket-heads, we were able to abandon the use of the wooden triangles. These foundations were found so comparatively steady and satisfactory that we never returned to the use of wooden pickets. The preparation of such foundations is rather laborious, but certainly not more so than picket-driving in hard ground. At intervals of 40 feet from the terminals of the ground standards a shallow concrete block was placed in the ground, which was designed to support the transferring-rod apparatus.

Bar-measure of Ground-Standards.

24. The Bar-measure was conducted as follows :—

The foot of a transferring-rod was placed in the starting terminal hole. The rod was rotated and the foot screws of its stand adjusted until its level showed that the rod was nearly vertical. The starting bar A having then been placed and clamped nearly in position, and a micrometer microscope attached to its backward end, the rod was rotated under the microscope and the collimation error of its index line measured with the micrometer screw. The remaining bars B, C, D, were then placed on the line, end to end, and then were aligned. The micrometer microscope was then detached from the back end of A, and attached to the forward end of D bar, being replaced by the ordinary bar-microscope. Coincidences were then made simultaneously by four observers, of A bar back-end with the rod index, of B with A, C with B, and D with C, and on all of the four observers signifying satisfaction, the fifth observer stationed at the forward end of D bar, having already placed there the second transferring-rod in position, he bisected with the micrometer wire both the bar division and the index line of the rod, recording the resulting readings of the micrometer head together with the readings of the level attached to the rod. The thermometer readings were then rapidly called. The bars were then taken forward, and the second rod left standing to serve as the back index-point in the second interval. The original terminal-rod, whose level has also been read at the start, is rotated as soon as it is free of the bars, and its level reading recorded in the reverse position. In the next succeeding measure the level of the standing rod (unrotated) was recorded at the moment of final coincidence of the rod-index with the bar-line, the bars being now placed in the order B, A, D, C, and the other operations followed as before, except that the indicated temperatures were now called before instead of after measure, they being thus called alternately before and after bisection in order to guard against the effects of the expansion in the interval. On arrival at the forward terminal the errors of collimation and level of the transferring rod are determined as at the beginning, and the value of the micrometer screw is examined by measuring with it a space of about five millimetres contained on a light standard scale which is temporarily attached to the bar-end.

It is to be observed that during an interval of some weeks, the temperature is likely so to vary that the sum of the bar-lengths may sometimes leave an increment in the 480-feet line which is outside the range of the micrometer screw, and it is therefore necessary before starting a measure to estimate the coming mean temperature and resulting increment, and to distribute the latter by setting the index of each forward rod a little before or behind the bar-index, so that the final increment may remain small.

Alignment. 25. The bars were aligned by means of the transit theodolite already described as in use on the baseline. The striding axis-level was applied. The aligner stood at first about the middle point of the line, and later at the forward terminal. The huts were moved forward with the measure, so as to keep the whole apparatus under cover.

Standard length. 26. The standard length is derived from :—

$$L = (B) + (i) + c_1 + c_2 + l_1 + l_2 + (l_3),$$

where

(B) is the sum of the bar-lengths

(i) is the sum of the micrometer intervals reduced to millimetres,

c_1 and c_2 are the collimation corrections,

l_1 and l_2 are the level corrections of the transferring apparatus at the terminals of the ground standards,

(l_3) is the sum of the corrections due to the movements of the levels of the transferring apparatus between the termination of the measurement of one 40-foot measurement and the commencement of the next.

Wire comparison. 27. In comparing the wire with the 480-feet standard, the pier terminals were occupied by the transferring rods, which alone were screened from the sun, the wire being fully exposed.

The wire intervals were set out by means of the tripod stands as on the baseline.

The plan was invariably pursued of going up and down the line four times each, thus making eight measures, or four sets of double journeys; the collimation error of the transferring apparatus being eliminated by its use equally in both positions of the rod. The transferring rod-level readings are recorded in both positions. The wire is reversed, end for end, after the first double journey, and again after the third, thus securing a variable illumination of the scales; while, since the forward scale reader travels equally in both directions for either position of the wire, he is forced to read an equal number of increments in each direction from the zero, *i.e.*, left to right, and right to left.

The circumstances of standardisation should thus effectually eliminate all systematic error in the adopted wire-length.

Wire-length. 28. The wire-length is computed from :

$$W = \frac{L}{6} + \frac{S}{6} + (l) + l_1 + l_2,$$

where

L is the absolute length of the standard line,

S is the sum of the wire-scale readings,

(l) is the sum of the corrections on level, having regard to the different heights of the tripod stands,

l_1 and l_2 are the level corrections for the transferring rods.

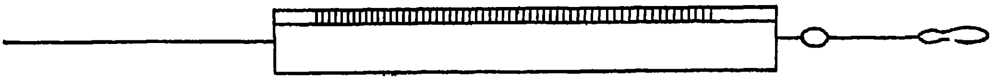
Comparison with 80-feet ground-standard.

29. In the application of a wire to the 80-feet ground-standard, the elevated terminals were again always defined by the transferring rods placed in the ground-terminals. The wire was suspended under the usual weights whose cords passed over the pulleys carried by wooden frames, the bases of which were formerly planted in the ground. As the straining frames so placed were found apparently to act as levers on the pier foundations, they were subsequently made simply to stand on the ground. The comparison of a wire with the standard was affected by the simultaneous readings of both scales, each in coincidence with the line on the horizontal face of the transferring rod. In this comparison the scale was brought up to the rod by tapping the standing frame into the required position, and numbers of readings were simultaneously made along the entire length of the scales, allowing them to slide from end to end, the scale faces lying nearly in the same horizontal plane as that of the top of the rod; that is to say, the scale face was horizontal.

Inclination of Scale Faces.

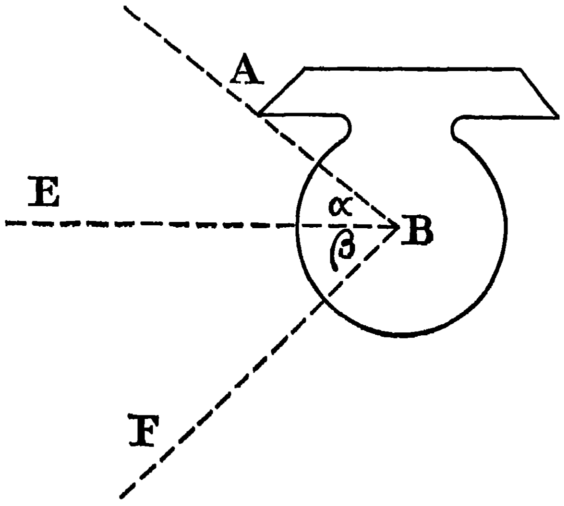
30. In the earlier standardisations there was always a large systematic difference between the apparent lengths of the wire as derived from the two standard lines. This proved to be due to the different vertical inclinations given to the scale-faces on the two lines. The form of scale attached to the more commonly used wire is exhibited in the following sections :—

Fig. I.



When the wire is in suspension, since the scale is lying longitudinally in a plane which is inclined to the horizon at an angle equal to the dip incidental to its position in the catenary curve, the rotation of the scale about the wire causes the radii, terminating in the scale edge, to describe circles about the wire, the planes of which are inclined to the vertical plane at an angle equal to the dip of the scale.

Fig. II.



Referring to Fig. II, the scale divisions being at A, and the wire passing through B, if AB $= r$, the angle EBA $= \alpha =$ the inclination of r to the horizon when the scale face is horizontal, and the angle EBF $= \beta =$ the inclination when the scale face is vertical; δ being the angle of longitudinal dip of the scale, the linear deflection of a scale division as the scale-face passes from the horizontal to the vertical must equal

$$r \,.\, \tan \delta \; (\sin \alpha + \sin \beta),$$

or

$$2r \,.\, \tan \delta \,.\, \sin \frac{\alpha + \beta}{2} \,.\, \cos \frac{\alpha - \beta}{2},$$

and when the two scales are involved, the change of apparent wire-length is equal to

$$4r \,.\, \tan \delta \,.\, \sin \frac{\alpha + \beta}{2} \,.\, \cos \frac{\alpha - \beta}{2}.$$

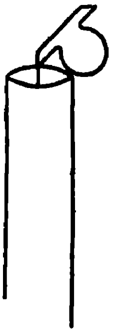
It is somewhat difficult to measure the length r, and the angle of vertical inclination of r for a given inclination of the scale face, because the scale is not always mounted very truly on the wire; but approximate values may be obtained by means of a fine scale, r being determined by measuring the diameters of the circles described by the scale-edge on rotating the scale through 180°, the wire being in suspension. The angle δ may be obtained by reading with a level telescope the divisions of a fine scale vertically placed alternately at each end of the wire-scale in suspension.

In this way we got for our wire No. 3 the mean value of r for both scales = 7·7 mm., the mean value of α = 42° 30′, and the dips of the two scales 1° 30′ and 1° 10′ respectively.

From these data, the calculated change of wire-length in passing from a horizontal scale-face to one vertical is 0·51 mm.; the measured value given by a number of direct experiments was 0·545 mm.

As used in the base-measures, the scale-faces are necessarily inclined to the horizon (depressed) at an angle of 60°, that being the inclination resulting from the contact invariably made by both the scale-edge and the cylindrical back of the scale with the spherical surface of the tripod-top.

Fig. III.



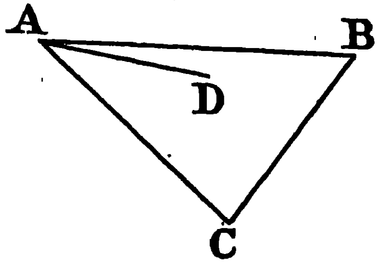
With this form of wire the computed change of apparent wire-length resulting from the rotation of its scale-face from a horizontal plane to one depressed 60° is :

$$\begin{aligned}\Delta &= 2r.\ \tan\delta\ \{\sin\alpha + \sin(60^\circ - \alpha)\} \\ &= 4r.\ \tan\delta.\ \sin 30^\circ.\ \cos 12\tfrac{1}{2}^\circ \\ &= 0.350 \text{ mm.}\end{aligned}$$

The measured difference derived from a number of special experiments on the 80-feet standard line was 0·370 mm. This last difference satisfied the relation between the apparent lengths of the measuring wire as derived from our two standards within the limits of the errors of observation, but it appeared that prior to the elucidation of the subject, the wire-scales at the extremities of the 480-feet line were placed against the terminal rod-faces at a mean angle of 20° depression, alike by each observer, and the resulting correction to the wire-length (+ 0·04 mm.), due to this failure to preserve the inclination of 60° which is enjoined in the intermediate points by the form of the tripod-head, has been applied to all the standard-lengths involved. At a later date we preserved the inclination of 60° by the use at the terminal of a paper angle-guide.

At Ottoshoop, two base-measures were made with a wire having the scale-form Fig. IV., the wire passing through D, and the divisions being at A.

Fig. IV.



The angle δ was about 1° 51′; and the mean r, 6·2 mm.

In this scale, since r is so close to the scale-face, the sum of the linear deflections of the two scales in passing from a scale-face horizontal to one vertical must be nearly equal to $2r.\ \tan\delta$, that is, 0·40 mm.

Seeing that the bearing-face of this scale is a plane, it is not possible, in its application to a tripod cylinder-head, to preserve any fixed angle of inclination of scale-face, and it is therefore a very dangerous form to use.

The third measure of the Ottoshoop line was made with the ordinary measuring wire, and no greater discordances than usual are disclosed. This is probably due to the preservation, in a great number of wire-comparisons, and over base-sections of considerable length, of a mean angle of inclination, alike on the Standard Line and on the Base-section. With wire-scales in which the divisions are not borne in the line of the wire, it is a highly important matter to preserve a fixed vertical inclination of the scale-face, both in the field and on the Standard Line. With the most modern form of Jaderin wires, the scale divisions are placed in the line of the wire, so that $r = 0$, and the indicated length is a constant for all inclinations of scale-face.

MEASURES ON THE FIVE BASELINES.

31. The following data represent the measures in the five baselines. In the computatation of the section-lengths the standard wire-lengths have been interpolated from the measured values for the limits of the periods.

AT BELFAST.

Bar-Measures of the 480-feet Standard.

		mm.	mm. mm.
July	7 & 8	146309·67	Mean = 146309·79 ± ·077
„	8 & 9	·55	
„	13	·41	
„	14	09·93	
„	29	10·45	
„	30	09·69	
Aug.	10	10·00	
„	11	09·64	

Wire-Lengths from 480-feet Standard.

Wire No. 1.

		mm.
June	5	24381·64
„	6	·76
„	10	·64
„	29	·45
July	3	·26
„	10	1·05
„	14	0·97
„	17	·89
„	19	·87
„	20	·85
„	22	·77
Aug.	11	·72
„	13	·63
„	17	·57
„	19	24380·59

Wire No. 3.

		mm.
June	6	24382·77
„	11	·69
„	29	·34
July	3	·32
„	10	2·06
„	16	1·91
„	19	·72
„	24	·76
„	25	·59
„	31	·55
Aug.	4	·48
„	5	·31
„	13	·26
„	15	24381·27

Base-Measures.

			mm.	mm. mm.
Section I*a*.	—July	23...	$122\,l + 1415$	Mean : $122\,l + 1409 \pm 5{\cdot}1$
	„	25...	$+ 1394$	
	Aug.	18...	$+ 1418$	
Section I*b*.	—July	22...	$92\,l - 880$	Mean : $92\,l - 878 \pm 2{\cdot}8$
	„	24...	$- 870$	
	Aug.	17–18...	$- 884$	

BELFAST—*continued.*

Base-Measures—continued.

			mm.		mm.	mm.
Section IIa.—July	1...	$100\,l +$	6879	Mean : $100\,l +$	6879	± 1·9
„	2...	$+$	6874			
Aug.	17...	$+$	6884			
Section IIb.—June	13–19...	$57\,l +$	6304	Mean : $57\,l +$	6307	± 1·2
„	15–20...	$+$	6310			
Aug.	15...	$+$	6306			
Section IIc.—July	15...	$77\,l +$	3772	Mean : $77\,l +$	3780	± 2·9
„	16...	$+$	3787			
Aug.	14...	$+$	3781			
Section IIIa.—July	17...	$89\,l +$	7425	Mean : $89\,l +$	7431	± 2·3
Aug.	4...	$+$	7437			
„	14...	$+$	7430			
Section IIIb.—July	18...	$98\,l +$	16054	Mean : $98\,l +$	16052	± 2·6
Aug.	3...	$+$	16045			
„	13...	$+$	16058			
Section IV.—Aug.	3...	$142\,l +$	9414	Mean : $142\,l +$	9426	± 4·7
„	12...	$+$	9425			
July	21...	$+$	9438			

where

$$l = \overset{\text{mm.}}{24380{\cdot}50}$$

$$L = 777\,l + \overset{\text{mm.}}{50406} \pm \overset{\text{mm.}}{9{\cdot}0}$$

$$= \overset{\text{mm.}}{18{,}994{,}055} \pm \overset{\text{mm.}}{9{\cdot}0}$$

AT OTTOSHOOP.

Bar-Measures of the 480-*Feet Standard.*

	mm.		mm.	mm.
Sept. 24............	146311·47	Mean :	146311·43	± ·021
„ 25............	·39			
Oct. 15............	·32			
„ 16	·50			
„ 28......	·46			

OTTOSHOOP—*continued.*

Wire-Lengths from 480-*Feet Standard.*

Wire A 18.

At temperature of equality with brass wire.

		mm.
Sept.	27	24383·54
„	30	·48
Oct.	3	·45
„	7	·48
„	10	·49
„	12	24383·45

Wire No. 3.

		mm.
Oct.	21	24381·28
„	23	·24
„	25	·19

Base-Measures.

Section	Month	Day	mm.	Mean (mm.)
Section I.—	Sept.	28	130 l + 670	Mean: 130 l + 669 ± 1·4.
	Oct.	12	+ 665	
	„	21–22	+ 672	
Section II*a*.—	Sept.	28–29	83 l + 1975	Mean: 83 l + 1967 ± 2·6.
	Oct.	11	+ 1964	
	„	22	+ 1963	
Section II*b*.—	Sept.	29	89 l − 562	Mean: 89 l − 566 ± 1·6.
	Oct.	10–11	− 570	
	„	22	− 567	
Section II*c*.—	Sept.	29–30	85 l + 2291	Mean: 85 l + 2291 ± 0·6
	Oct.	9–10	+ 2289	
	„	24	+ 2292	
Section III.—	Oct.	1	131 l − 2612	Mean: 131 l − 2610 ± 0·8.
	„	9	− 2608	
	„	24	− 2610	
Section IV*a*.—	Oct.	1–2	75 l − 412	Mean: 75 l − 409 ± 2·0.
	„	8	− 403	
	„	24–25	− 412	
Section IV*b*.—	Oct.	2	52 l − 1757	Mean: 52 l − 1757 ± 0·4.
	„	8	− 1756	
	„	25	− 1758	
Section IV*c*.—	Oct.	2	70 l + 5484	Mean: 70 l + 5490 ± 2·0.
	„	7–8	+ 5494	
	„	25	+ 5491	

OTTOSHOOP—*continued.*

Base Measures—continued.

where

$$l = \overset{\text{mm.}}{24382{\cdot}00}$$

$$L = 715\,l + \overset{\text{mm.}}{5075} \pm \overset{\text{mm}}{4{\cdot}5}$$

$$= \overset{\text{mm.}}{17{,}438{,}205} + \overset{\text{mm.}}{4{\cdot}5}$$

AT WEPENER.

Bar-Measures of the 480-Feet Standard.

	mm.
1903.	
Nov. 26	146317·41
„ 30	·15
Dec. 1	·30
„ 8	·59
„ 12	·32
„ 18	·61
„ 18	·48
„ 28	·62
„ 28	·54
1904.	
Jan. 2	·51
„ 2	·57
„ 7	·72
„ 7	·84
„ 8	·79
„ 8	146317·75

Mean: $\overset{\text{mm}}{146317{\cdot}55}$

NOTE.—This line appears to have expanded. Regarding its length as inconstant, the probable errors given by the observations are:—

For a single measure.........±·035

For a pair ....±·025

Wire-Lengths.

Wire No. 3

		mm.
1903.	Dec. 1	24381·29
	„ 6	·24
	„ 13	·24
	„ 17	·32
	„ 29	·31
1904.	Jan. 1	24381·34

WEPENER.

Base-Measures.

		mm.	mm. mm.
Section I.—Dec.	2–3…	$163\,l + 9506$	Mean : $163\,l + 9504 \pm 1{\cdot}3$
"	16…	$+ 9500$	
"	29–30…	$+ 9505$	
Section II.—Dec.	3…	$125\,l + 141$	Mean : $125\,l + 143 \pm 2{\cdot}0$
"	16…	$+ 146$	
"	30…	$+ 135$	
Jan.	6…	$+ 148$	
Section III.—Dec.	3–4…	$210\,l + 9222$	Mean ; $210\,l + 9222 \pm 0{\cdot}0$
"	15–16…	$+ 9222$	
"	30–31…	$+ 9222$	
Section IV.—Dec.	4–5…	$111\,l - 117$	Mean : $111\,l - 117 \pm 0{\cdot}6$
"	15…	$- 119$	
"	31…	$- 116$	
Section V.—Dec.	5…	$165\,l - 716$	Mean : $165\,l - 712 \pm 1{\cdot}4$
"	14…	$- 712$	
"	31…	$- 709$	
Section VI.—Dec.	5–6…	$113\,l + 11182$	Mean : $113\,l + 11181 \pm 1{\cdot}4$
"	14…	$+ 11177$	
Jan.	1…	$+ 11184$	

where

$$l = \overset{\text{mm.}}{24381{\cdot}20}$$

$$L = 887\,l + \overset{\text{mm.}}{29221} \pm \overset{\text{mm.}}{3{\cdot}2}$$

$$= \overset{\text{mm.}}{21{,}655{,}345{\cdot}00} \pm \overset{\text{mm.}}{3{\cdot}2}$$

AT KROONSTAD.

Bar-Measures of the 480-feet Standard.

		mm.	mm.
Feb.	3…………	146320·55	Mean : 146320·55
"	4…………	·74	
"	8…………	·55	
"	8…………	·35	
"	15…………	146320·62	Mean : 146320·65
"	15…………	·64	
"	18……… ..	·68	

KROONSTAD—*continued.*

Bar-Measures of the 480-feet Standard—continued.

		mm.		mm.
Mar.	3	146320·89	Mean :	146320·91
„	3	·98		
„	4	·85		
„	4	·94		
„	9	·91		
„	18	146321·14	Mean :	146321·28
„	18	·50		
„	19	·28		
„	19	·18		

NOTE.—This is evidently an expanding line. Regarding the length as inconstant, the probable errors given by the observations are :—

	mm.
For a single measure	±·064
For a pair	±·045

Wire-Lengths.

Wire No. 3.

1904.		mm.
Feb.	4	24381·50
„	7	·51
„	12	·52
„	18	·54
Mar.	5	·56
„	8	·61
„	17	·65
„	22	24381·63

Base-Measures.

			mm.		mm.	mm.
Section I.—Feb.	6...	66 l	− 1621	Mean :	66 l − 1622	± 0·7
„	6...		− 1624			
Mar.	6...		− 1621			
Section II.—Feb.	6...	202 l	− 641	Mean :	202 l − 641	± 1·0
„	7...		− 643			
Mar.	6...		− 638			
Section III.—Feb.	5...	138 l	− 209	Mean :	138 l − 214	± 2·0
„	7...		− 219			
Mar.	7...		− 215			
Section IV.—Feb.	13...	134 l	− 4785	Mean :	134 l − 4782	± 1·6
„	13–14...		− 4777			
Mar.	20...		− 4783			
Section V.—Feb.	16...	78 l	+ 9	Mean :	78 l + 12	± 1·2
„	17...		+ 15			
Mar.	20...		+ 13			

KROONSTAD—*continued.*

Base-Measures—continued.

		mm.	mm.
Section VI.—Feb.	16–17...	$196\,l - 3157$	Mean: $196\,l - 3163 \pm 2{\cdot}9$
„	17...	$- 3171$	
Mar.	20–21...	$- 3160$	

where

$$l = 24381{\cdot}50 \text{ mm.}$$

$$L = 814\,l - 10410 \pm 4{\cdot}2 \text{ mm.}$$

$$= 19{,}836{,}131 \pm 4{\cdot}2 \text{ mm.}$$

AT PIETERSBURG.

Bar-Measures of the 480-Feet Standard.

	mm.	mm.
May 25	146308·76	Mean: 146308·66 ± ·026
„ 26	·64	
June 2	·56	
„ 7	·53	
„ 13	·50	
„ 18	·62	
„ 20	·87	
„ 25	·62	
„ 26	·79	
„ 27	146308·73	

Wire-Lengths.

		mm.
May 26	Wire No. 3	24381·52
June 2	„ „ 1	24380·75
„ 7	„ „ 1	·78
„ 13	„ „ 1	·76
„ 18	„ „ 1	·76
„ 20	„ „ 1	·77
„ 25	„ „ 1	24380·75

Base-Measures.

		mm.	mm.
Section I.—May	27...	$150\,l + 270$	Mean: $150\,l + 277 \pm 3{\cdot}5$
June	12...	$+ 273$	
„	20–21...	$+ 287$	
Section II.—May	27–28...	$200\,l - 140$	Mean: $200\,l - 137 \pm 1{\cdot}7$
June	12...	$- 139$	
„	21...	$- 132$	
Section III.—May	28...	$180\,l - 88$	Mean: $180\,l - 91 \pm 1{\cdot}0$
June	11...	$- 93$	
„	21–22...	$- 91$	

PIETERSBURG—*continued.*

Base Measures—continued.

			mm.		mm.	mm.
Section IV.—May	29...	220 l	+ 13403	Mean: 220 l	+ 13405	± 0·8
	June 10–11...		+ 13404			
	„ 22...		+ 13407			
Section V.—May	29–30...	192 l	− 601	Mean: 192 l	− 606	± 1·7
	June 10...		− 608			
	„ 22–23...		− 609			
Section VI.—May	30...	144 l	+ 276	Mean: 144 l	+ 270	± 2·1
	June 9–10...		+ 268			
	„ 23...		+ 266			
Section VII.—May	31..	177 l	− 1042	Mean: 177 l	− 1040	± 1·3
	June 9...		− 1042			
	„ 23–24...		− 1036			
Section VIII.—May	31...	130 l	− 5460	Mean: 130 l	− 5462	± 1·0
	June 8–9...		− 5462			
	„ 24...		− 5465			

where:

$$l = \overset{\text{mm.}}{24381{\cdot}00}$$

$$L = 1393\,l + \overset{\text{mm.}}{6616} \pm \overset{\text{mm.}}{5{\cdot}2}$$

$$= \overset{\text{mm.}}{33{,}969{,}349} \pm \overset{\text{mm.}}{5{\cdot}2}$$

Probable error. 32. In the foregoing data, the probable errors quoted are those deduced from the discordances in the repeated measures of the sections. In the cases of the Wepener and the Kroonstad lines, since the standard lines are assumed to have been inconstant in length, an independent value of the standard-length has been used for each individual base-measure, and the derived probable errors should thus include not only the accidental errors of measure, but the systematic errors as well.

In the other lines—those at Belfast, Ottoshoop, and Pietersburg—since the adopted standard-lengths are constant for the whole periods of measure, one must add to the derived probable errors the systematic errors:

At Belfast............129·5 × 0·077 = 10·0
At Ottoshoop........119·2 × 0·021 = 2·5
At Pietersburg......232·2 × 0·026 = 6·0

The probable errors are then:—

At Belfast.........10·0 + 9·0 = ± 19·0 = approx. $\frac{1}{1,000,000}$

At Ottoshoop..... 2·5 + 4·5 = ± 7·0 = „ $\frac{1}{2,491,000}$

At Wepener...... ± 3·2 = „ $\frac{1}{6,767,000}$

At Kroonstad.... ± 4·2 = „ $\frac{1}{4,723,000}$

At Pietersburg.. 6·0 + 5·2 = ± 11·2 = „ $\frac{1}{3,033,000}$

In viewing these errors, one finds the Belfast error considerably greater than any other. This may fairly be regarded as mainly due to want of skill, of knowledge, and of efficient co-operation, the Belfast measure having been of an experimental nature. The apparent superiority of the measures at Wepener and Kroonstad, where the systematic errors enter variably into the individual measures, appears to indicate that the true errors of Bar-measure are really smaller than those derived from an extended series of measures of a standard line; in other words that the standard piers on any line have not been steady for any long period. There are, however, not sufficient observations on which to base a discussion of practical value, and in the absence of definite knowledge, the potential pier-displacements must be considered as errors of observation.

Sources of Probable Error.

33. The principal sources of the theoretical probable error of a wire base-measure, expressed, as these measures must at present be, in terms of the adopted mean lengths of the Standard Bars during their several applications to the Standard Line, are :—

(*a*) The error of the adopted value of the length of the standard line in terms of the bars.

(*b*) The error of the adopted relation of the wire-length to the standard line.

(*c*) The accidental errors of the wire-scale readings during a base-measure.

(*d*) The error due to imperfection of levelling.

(*e*) The cumulative error due to small errors of alignment.

With regard to (*a*), the effect of this error is naturally proportional to the number of times that the baseline contains the standard line. The error of the standard line is a function of the conditions of measure, and it is therefore not reasonably to be regarded as a constant for all the standard lines, although the apparatus may in all cases be identically the same, and employed with equal degrees of skill. With our Bar Apparatus, experience shows that we get a much smaller probable error when the temperature is fairly constant and the air dry, than we do when there are rapid changes of temperature or quickly diminishing humidity. By either of the adverse conditions, the temperature of the bars, in their light wooden cases, is quickly and irregularly disturbed, and is therefore difficult to record.

The error (*b*) may be regarded as constant for all base-lines measured under similar mechanical circumstances.

In an extended series of comparisons of a wire with the 480-feet standard, we find extreme discordances amongst the individuals of a set of four double measures, conducted as I have described, of 0·15 mm. for the wire-length in terms of the standard. It would appear from this that the probable error of an individual double measure is about 0·025 mm., and a set of four, on which our adopted length is always founded, about 0·012 mm. This error is evidently systematic, but is independent in each of several measures.

For convenience of computation, its effect may be added to that of (*a*), so that

$$\mu_w = \sqrt{\frac{\mu^2_a}{6} + \mu^2_b}$$

In considering the magnitude of (*c*), one observes that in a series of wire-measures of a constant distance, the range of scale reading is about 0·15 mm., so that the probable error (*c*) for each wire-interval in a line may be regarded as not exceeding 0·03 mm.

The error (*d*) in any baseline is dependent on the several gradients of the individual wire-intervals, and is thus not to be computed without greater labour than the present discussion warrants. The level-correction to a wire-interval is computed from

$$l = \frac{h^2}{2S}$$

where *h* is the elevation of one terminal above the other, and S is the wire-length.

By experiment, the probable error of a measure of h in the field does not exceed 1·5 mm. Adopting this value, and, in place of the relative elevations of the terminals of the individual intervals, substituting in any line the average gradient of an interval, (d) will be found to be comparatively small. The mean gradients of the lines are :

At Belfast 1/35, Ottoshoop 1/112, Wepener 1/57, Kroonstad 1/49, and at Pietersburg 1/78.

Since

$$\mu_L^2 = \frac{n}{4S^2} \cdot \mu_h^2$$

from source (d)

$$r_L = \pm \cdot 6745 \sqrt{\frac{4 \cdot 93 \; n h^2}{S^2}}$$

mm.

= at Belfast ± 1·2

= „ Ottoshoop ± 0·4

= „ Wepener ± 0·8

= „ Kroonstad ± 0·9

= „ Pietersburg ± 0·7

With respect to the error (e), the adherence to the line of the principal section-points and of the intermediate station points is so close that, in view of the distances between such points, the resulting errors of measure are insensible. In setting the tripods, one may assume that the cylinder-heads, of which numbers are set independently from an instrument station, are each aligned within 6 mm., so that, in a wire-interval, the limit of the departure from the direction of line may be regarded as the angle subtended by 12 mm. at the distance of the wire-length, and the probable error of inclination as not exceeding the angle subtended by 2·5 mm.

The linear correction is $l = \frac{e^2}{2S}$, where s is the wire-length.

In a complete base-measure, the probable error from the source (e) is

$$r_L = - \cdot 6745 \, n \sqrt{\frac{e^2}{S^2} \cdot \mu^2_e}$$

The computed values for this expression in the different bases are :

At Belfast, Ottoshoop, Wepener, and Kroonstad—all 0·02 mm., and at Pietersburg, 0·04 mm.

Collecting the sources of theoretical error in a baseline, neglecting the effects of errors of alignment, and noting that the length is computed from

$$L = n \cdot w + s + l$$

where n is the number of wire-intervals, w is the adopted standard wire-length, s is the sum of the scale readings, and l is the sum of the level corrections ; the probable error of a single measure

$$r_L = \pm \cdot 6745 \cdot \sqrt{\mu^2_{nw} + \mu^2_s + \mu^2_l}$$

and of the mean of three measures with a common standard

$$r_L = \pm \cdot 6745 \cdot \sqrt{\mu^2_{nw} + \frac{\mu^2_s + \mu^2_l}{3}}$$

when the standards are independent,

$$r = \pm \cdot 6745 \cdot \sqrt{\frac{\mu^2_{nw} + \mu^2_s + \mu^2_l}{3}}$$

and

$$\mu_{nw} = n \cdot \sqrt{\mu^2_{\frac{a}{6}} + \mu^2_b}$$

The following values for the symbols are derived from the measures, or in the cases of μ_s and μ_l adopted from the results of special experiment.

	n	μ_a 6	μ_b	μ_{mw}	μ_s	μ_l
		mm.	mm.	mm.	mm.	mm.
At Belfast	777	0·019	0·018	20·357	1·25	1·8
,, Ottoshoop	715	0·006	0·018	13·585	1·19	0·6
,, Wepener	887	0·004	0·018	16·321	1·32	1·2
,, Kroonstad	814	0·007	0·018	15·710	1·26	1·3
,, Pietersburg	1393	0·006	0·018	26·467	1·66	1·0

These give

For Belfast with constant standard, $r_L = \pm \overset{\text{mm.}}{13{\cdot}76} = \frac{1}{1{,}380{,}000}$

,, Ottoshoop ,, ,, ,, $r_L = \pm\ 9{\cdot}17 = \frac{1}{1{,}902{,}000}$

,, Wepener ,, independent standards $r_L = \pm\ 6{\cdot}39 = \frac{1}{3{,}389{,}000}$

,, Kroonstad ,, ,, ,, $r_L = \pm\ 6{\cdot}16 = \frac{1}{3{,}220{,}000}$

,, Pietersburg ,, constant standard $r_L = \pm\ 17{\cdot}86 = \frac{1}{1{,}902{,}000}$

A. SIMMS.

REPORT OF MR. COCHRANE ON BASE LEVELLING.

1. For observing the differences of height between successive tripod tops the instruments used were :—

(*a*) A Cooke's reversible engineer's level, or a Troughton & Simms' 12-in. dumpy level, both being available. They were equally suitable, and were used instead of the small instrument supplied with the Jaderin Base apparatus because, being of greater optical power, a larger number of tripods could be seen from one position, and, being heavier, the trouble from wind vibrations was reduced.

(*b*) The Staff supplied with the Base apparatus was two and a-half metres long, graduated on one side to decimetres and centimetres, and on the other to sevenths of a metre and decimals of that seventh. The former divisions were in black, and the latter red. A weak point was that the graduations were printed on paper gummed upon the staff, and after a little friction from use and exposure to damp the paper peeled off. This staff was used for a time, but was soon discarded, and a staff made by Messrs. Troughton & Simms, the private property of Mr. A. Simms, was substituted. It was divided in the same way, but painted directly on the wood. The staff was four metres long and was made to telescope down to a length of 2·2 metres for use on level ground. A small circular level was attached to enable the staff-holder to keep the staff in a vertical position while it was being read.

2. So soon as the base measurers left a pair of tripods, the staff-holder placed the staff on the top of the back tripod, showing the red face, graduated to sevenths, first, and then the black face graduated to decimetres; then he passed on to the next tripod and did the same. After entering the readings of the staff for the two tripods, the difference of height as measured on the black face was compared with that on the red face by multiplying the former by seven, and a check was thus obtained before the staff-holder passed on to the following tripods. So soon as the differences of height were checked, native runners carried the tripods forward for continuing the alignment.

3. The tripods were numbered consecutively, and care was taken, in placing, to keep them in numerical order, and thus minimise the risk of the leveller omitting any of them.

4. It was necessary to select a tall strong native to act as staff-holder, because the lower end of the staff is some distance from the ground, and in a high wind it is difficult to hold it vertical.

5. On comparatively level ground, the successive differences of height between the whole set of ten tripods was sometimes observed without its being necessary to take up a fresh position with the levelling instrument. But the line was seldom flat enough for this, and usually only three or four tripods were observed from one position. In a few places the gradient was so steep that the four-metre staff was not long enough to include even one difference of height between two tripods, and an intermediate point had to be used, the staff being placed on a metal foot rounded at the top and having four spikes underneath for driving into the ground about midway between the two tripods. If the ground was very stony, a sharp-pointed rock could generally be found to use instead of the metal foot.

6. With two aligners placing the tripods, and the measurers using only one wire, the leveller has hard work to keep up with them on an average gradient. On very steep parts of the line, where the instrument had to be constantly moved to a new position, the measurers were sometimes kept waiting.

7. The following tables (A and B) were formed for reducing the measured lengths to the horizontal from the formula :—

$$r = \frac{\Delta h^2}{2L} + \frac{\Delta h^4}{8L^3} + \frac{\Delta h^6}{16L^5}$$

Table A.

ARGUMENT: DIFFERENCE OF HEIGHT ON BLACK FACE (DECIMETRES).

Δh	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
dm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0	..	0·002	0·008	0·018	0·033	0·051	0·074	0·100	0·131	0·166
1	0·205	0·248	0·295	0·347	0·402	0·461	0·525	0·593	0·664	0·740
2	0·820	0·904	0·992	1·085	1·181	1·282	1·386	1·495	1·607	1·724
3	1·845	1·971	2·100	2·233	2·370	2·512	2·657	2·807	2·961	3·119
4	3·281	3·447	3·617	3·791	3·969	4·152	4·339	4·530	4·724	4·923
5	5·127	5·334	5·545	5·760	5·980	6·203	6·431	6·662	6·898	7·138
6	7·383	7·631	7·883	8·139	8·400	8·664	8·933	9·205	9·483	9·763
7	10·049	10·338	10·631	10·929	11·231	11·536	11·846	12·160	12·478	12·800
8	13·126	13·456	13·791	14·130	14·473	14·819	15·170	15·525	15·883	16·247
9	16·614	16·985	17·361	17·741	18·124	18·512	18·904	19·300	19·701	20·105
10	20·513	20·926	21·343	21·764	22·188	22·617	23·050	23·487	23·928	24·373
11	24·823	25·277	25·735	26·197	26·662	27·132	27·606	28·084	28·567	29·053
12	29·544	30·039	30·538	31·040	31·547	32·059	32·575	33·094	33·618	34·145
13	34·677	35·213	35·753	36·297	36·845	37·398	37·955	38·515	39·080	39·649
14	40·222	40·799	41·380	41·966	42·555	43·149	43·747	44·349	44·955	45·565
15	46·179	46·797	47·420	48·046	48·677	49·312	49·951	50·594	51·241	51·892
16	52·548	53·208	53·871	54·540	55·212	55·888	56·568	57·252	57·940	58·633
17	59·330	60·031	60·736	61·445	62·158	62·876	63·598	64·324	65·053	65·787
18	66·525	67·267	68·013	68·764	69·519	70·278	71·041	71·808	72·578	73·353
19	74·133	74·917	75·704	76·496	77·292	78·093	78·897	79·706	80·518	81·335
20	82·156	82·981	83·810	84·643	85·481	86·323	87·169	88·019	88·873	89·731
21	90·598	91·459	92·330	93·205	94·084	94·967	95·854	96·745	97·641	98·540
22	99·444	100·352	101·264	102·180	103·101	104·026	104·955	105·888	106·825	107·766
23	108·711	109·660	110·614	111·572	112·534	113·500	114·470	115·445	116·424	117·407
24	118·394	119·385	120·380	121·379	122·382	123·390	124·402	125·418	126·438	127·462
25	128·491	129·524	130·560	131·601	132·646	133·696	134·750	135·807	136·870	137·936
26	139·006	140·080	141·159	142·242	143·329	144·420	145·515	146·614	147·719	148·827
27	149·938	151·054	152·174	153·299	154·428	155·561	156·698	157·839	158·985	160·135
28	161·289	162·447	163·609	164·776	165·946	167·121	168·300	169·483	170·670	171·861

Table B.

ARGUMENT: DIFFERENCE OF HEIGHT ON RED FACE (SEVENTHS OF A METRE).

Δh	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
dm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0	..	0·004	0·017	0·038	0·067	0·105	0·151	0·205	0·268	0·339
1	0·418	0·506	0·603	0·707	0·820	0·941	1·071	1·209	1·356	1·511
2	1·674	1·845	2·025	2·214	2·411	2·616	2·829	3·051	3·281	3·520
3	3·766	4·022	4·285	4·557	4·838	5·127	5·424	5·729	6·043	6·366
4	6·696	7·035	7·383	7·738	8·102	8·475	8·856	9·245	9·643	10·049
5	10·464	10·886	11·318	11·757	12·205	12·661	13·126	13·599	14·081	14·571
6	15·069	15·576	16.091	16·614	17·146	17·686	18·235	18·792	19·357	19·931
7	20·513	21·104	21·703	22·310	22·926	23·550	24·182	24·823	25·472	26·130
8	26·796	27·471	28·153	28·845	29·544	30·252	30·969	31·694	32·427	33·169
9	33·919	34·677	35·444	36·219	37·003	37·795	38·596	39·405	40·222	41·048
10	41·882	42·724	43·575	44·434	45·302	46·178	47·063	47·956	48·858	49·767
11	50·686	51·613	52·548	53·491	54·443	55·404	56·373	57·350	58·335	59·330
12	60·333	61·344	62·363	63·391	64·427	65·472	66·525	67·587	68·657	69·736
13	70·822	71·917	73·021	74·134	75·254	76·384	77·521	78·667	79·822	80·985
14	82·156	83·336	84·524	85·721	86·926	88·140	89·362	90·593	91·832	93·079
15	94·335	95·600	96·873	98·154	99·444	100·742	102·049	103·365	104·688	106·021
16	107·361	108·711	110·068	111·435	112·809	114·192	115·584	116·984	118·393	119·810
17	121·285	122·670	124·112	125·563	127·023	128·491	129·968	131·453	132·946	134·449
18	135·959	137·478	139·006	140·542	142·087	143·640	145·202	146·772	148·351	149·938
19	151·534	153·138	154·751	156·372	158·002	159·641	161·288	162·943	164·608	166·280
20	167·961	169·651	171·349	173·056	174·771	176·495	178·228	179·969	181·718	183·477

The table for the black face was written in black ink, and the other face in red ink.

8. These tables were computed for L = 24385 millimetres. For greater differences of height, the exact measured length was used for computing the correction for reduction to horizontal. The corrections to Tape-measures had also to be specially computed.

9. The following extract from a Field Book shows how the observations were entered :—

Set.	Tripod.	Reading on Red Face.	Diff.	Reading on Black Face	Diff.	For check. Diff. × 7.
		$\frac{m}{7}$	$\frac{m}{7}$	dm.	dm.	$\frac{m}{7}$
III.	2	4·27		6·10		
			+ 1·35		+ 1·93	1·35
	3	2·92		4·17		
			— 0·16		— 0·23	0·16
	4	3·08		4·40		
			+ 1·09		+ 1·56	1·09
	5	1·99		2·84		
			+ 0·74		+ 1·05	0·74
	6	1·25		1·79		
	6*	4·39		6·27		
			+ 0·27		+ 0·39	0·27
	7	4·12		5 88		

* Instrument moved to a fresh position.

10. From the above observations, the corrections for reduction to horizontal were derived from Tables A and B, as follows :—

Set.	Tripods.	Diff. on Red Face.	Corrections.	Diff. on Black Face.	Corrections.
		$\frac{m}{7}$	mm.	dm.	mm.
III	2—3	1·35	0·76	1·93	0·76
	3—4	0·16	0·01	0·23	0·01
	4—5	1·09	0·50	1·56	0 50
	5—6	0·74	0·23	1·05	0·23
	6—7	0·27	0·03	0·39	0·03

A. COCHRANE.

REPORT OF MR. GUMMER ON ALIGNMENT OF TRIPODS DURING BASE MEASUREMENTS.

1. The small aligning instrument supplied with the Jaderin apparatus was made to fit on the top cylinders of the tripods, but as it necessitated placing these always vertical and thereby causing delay, it was discarded and two small theodolites were used.

2. On all the baselines where only one measuring wire was used, it was found necessary to have two aligners, one to align a series of tripods and the other to go ahead and set up his instrument so as to be ready to continue the alignment so soon as the previous series of tripods was fixed. Before the measuring party went into the field, small flags were aligned at intervals of about 300 yards between the section points for use of the aligners.

3. For long distances a black vane with a white cross supplied with the apparatus was placed on the top cylinder of the tripod. (*See* Photo No. 29).

4. It was found necessary over either very rocky or very soft ground to sling large stones on the tripods to ensure their steadiness.

5. When leaving off a measure at any other than a terminal or sectional point, the position of the tripod was transferred to a wooden picket driven into the ground with a pencil mark on it. As a right angle was not accurately set off from these points, the tripod of the instrument was, as a rule, left standing till the measurement was continued. On the rare occasions when it was removed, the points where the tripod legs rested were carefully marked and protected.

6. A good deal of trouble was caused at the Wepener Base by cattle and sheep rubbing against the small flags on the base and breaking them off or knocking them down, and on several occasions the aligner had to place his instrument by trial, which caused delay to the measuring party. The country in that district was bare of stones so no small beacons could be erected.

7. The final adjustment of the cross lines of the tripods over the terminals and section points was affected by means of a theodolite placed at right angles to the alignment and three or four yards from it, accuracy being ensured by a striding level. The instrument was also reversed on its axis to eliminate all possible error. On steep gradients the striding level was always used in a similar way. One aligner as a rule fixed from 10 to 14 tripods over a distance of about 300 yards; the error of their alignment could not have exceeded $\frac{1}{4}$-inch.

8. The instruments used were carefully tested for instrumental errors before leaving and on returning to camp.

W. A. GUMMER.

THE "FOLLOWING" REPORT OF MR. BANKS AS OBSERVER DURING BASE MEASUREMENT.

1.—STRAINING APPARATUS.

(*a*) The Jaderin apparatus was greatly improved upon by the introduction of weights and pulleys in place of dynamometers. It was found that the straining poles could be manipulated by natives, who soon learnt what was required of them, and were in addition very steady at the time of taking the readings. The pulley bearings require to be frequently oiled to guard against friction.

(*b*) With regard to suitable cords, many were tried, and it was found that the best for the purpose was the ordinary woven blind cord, which has no twist, and satisfactorily stood the strain for months under considerable exposure.

(*c*) In attaching the cords to the weights, it is advisable to have a spare end, which can be knotted loosely to the main cord, as it sometimes happened that the straining pole had to be placed a little farther away from the tripod than usual, consequent on uneven ground, &c., when in order to allow the weight to hang free from the pulley, the spare end was used and the weight knotted near the end. In order to have a proper control of the weight, in keeping it steady during measurement and free from grass and other obstructions, a native was specially detailed to look after it. (*See* Photos Nos. 17 and 18.)

2.—WIRES.

(*a*) The most important duty of the "following" observer was to take proper care of the measuring wires in uncoiling, coiling, and storing. In "Nature," Vol. 71, No. 1,832, M. Ch. Ed. Guillaume refers to an aluminium drum for this purpose. He does not describe it, but gives an illustration as to how it is used.

(*b*) In a country like South Africa, where equipment has to be transported along the base lines over rough roads and drifts, a drum like the one shown would, unless very carefully packed, soon become useless through dents, &c., and, considering that the wires can be uncoiled and coiled very easily, and with safety after a little practice, a coiling drum can be dispensed with.

(*c*) The operation of uncoiling a wire is very simple. One end of the wire is held at the swivel, while the manipulator holds the remainder of the coils in his hand in such a way that the scale lies in the hollow of his hand. He then walks backwards, paying out hand over hand, always taking care to grip the coils where the scale lies. This prevents the scale swinging, and so weakening the wire at the junction with the scale. It is safer for the manipulator to walk backwards than for the one holding the swivel to do so, as there is less chance of jerking.

(*d*) In coiling the wire after use, it is again held at one end by the swivel. The other end is grasped at the scale, in the left hand. The right hand is then stretched out and takes hold of the wire at an arm's length with the thumb and fore-finger. Then, with a gentle swing in a left-handed direction, at the same time stepping forward a pace, he completes a single coil, which is held in position by the left hand. The person holding the swivel must also in this case stand still, and watch that the swivel turns with every coil, otherwise there is a chance of the wire kinking. This operation is repeated until the whole wire is coiled, when it is tied in two places, near the scales, and hung in a safe place for the night.

(*e*) For transport purposes, to or from the base-line, the wires were packed in wood-shavings in a shallow box.

(*f*) When the wires were stored for any time, they were first cleaned and then smeared with a small quantity of vaseline, which was always wiped off before further use. They were also wiped every time they were uncoiled, as the operation of uncoiling causes them to touch the ground.

(*g*) It is suggested that the spindles and sockets of the swivels should be properly lathe-turned, so as to ensure a free and correct movement. Those supplied with the wires were not of this kind, and, until they had seen some service and been worked by hand, occasionally gave some trouble.

3.—MEASURING THE INTERVALS.

(*a*) After the initial tripod is set over the terminal block, it is the duty of the following observer to carefully watch that the tripod is not touched in any way. He must also see that the strainer, in placing his pole and bringing the scale of the wire into position, on this and all subsequent tripods, does not knock them. If this happens, the following-observer must call for a repetition of the previous interval to make sure whether the tripod has been moved or not. When the wire is hooked on, and the strainers have brought it into position (that is, lightly touching the tops of the tripod cylinders), the following observer, after making sure that the wire is not in contact with any grass or other obstacle, and is running free on the pulleys, takes hold of the scale lightly with thumb and finger of the left hand, and brings the zero division in conjunction with the cross division on the cylinder. He may steady the scale by letting one finger come in contact with the side of the tripod cylinder, but must take care not to grip it, as the wire must run entirely free. As soon as he sees the scale steady, he makes an accurate setting with the aid of a reading glass, gives the signal to the observer at the other end of the wire, who takes the reading and books it. After the reading is taken, the wire is raised by the strainers and brought to one side away from the tripods, so that, in releasing the weights from the wire, there is less chance of a tripod getting a knock. The wire is then unhooked and the party proceeds, the two observers carrying the wire, the observer at the following end watching that the wire is not subjected to any rough treatment. This is essential in the case of uneven ground, fences, or bush.

(*b*) If a wire-fence crossed the line of measurement, the measuring wire was passed through the fence at about the height required, and one of the weight carriers was sent to hold the strand in the fence away from the measuring wire, to ensure that there was no chance of its catenary being altered. When long grass was encountered it was trampled down or cut.

(*c*) The reading glasses supplied were made to fit on the cylinders of the tripods. This is not really necessary as it means waste of time, and, moreover, a possibility of movement of the tripod in fixing the glass to the cylinder. A glass with an attachment about three inches long terminating in a ring to fit the little finger of the hand answers admirably. The observer can carry it hanging on the finger without it interfering in any way with the handling of the wire.

(*d*) The two carrying rings are not required, especially when the wire is fitted with a ring between the scale and the swivel, large enough to admit of one's finger. When it was found necessary to "hang up" the wire temporarily, the weight carriers were entrusted with it, holding it by a piece of wood passed through the hook of the swivel, the wood being gripped securely with a finger on each side of the swivel. This method was found to answer very satisfactorily, especially when two wires were in use, and wire carriers were required.

4.—STANDARDISATION OF WIRES.

(*a*) On a partially cloudy day, it was found that the levels on the rods of the transferring apparatus would not remain steady, because of the heating and cooling of the metal of the stands. A slight breeze on a clear day also had the same effect. The conical tubes of the stands were therefore covered with two or three thicknesses of flannel to obviate this, and the levels remained much steadier during observation, care being taken by the observer not to stand so as to throw a shadow on any of the foot screws.

(*b*) When the party went to Johannesburg to lay down the ground-standards, the work on which had to be done without huts, a proper covering for the transferer stands was made in such a way that it sheltered the tube and also the foot screws from the sun's rays. The covering consisted (*see* Photo No. 18) of a thick layer of cotton-wool wrapped round the tube and covered with calico attached to a cardboard circle fitted about three inches above the foot screws. This circle, which was also padded with cotton-wool, projected sufficiently so as always to keep the foot screws in the shade, provided the measurement did not take place when the sun was very low. With this covering the levels gave no trouble.

E. H. BANKS.

REPORT OF MR. LOWINGER ON GEODETIC LEVELLING.

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1. The Levelling party, which consisted of an observer, an assistant, and a transport conductor, with the necessary transport and camp equipment, was constituted in July, 1904, and after some time spent in preliminary work in Pretoria, began operations at Lourenço Marques on August 15. Introductory.

Owing to the severe illness of the observer, and the near approach of summer, when it is impossible to work in the low veld, a gap was left in the work between Malelane, 88 miles from Lourenço Marques, and Machadodorp, 193 miles from the sea. Mr. A. Cochrane, of the headquarters staff, carried on the work from Machadodorp to Balmoral, connecting *en route* with the South Terminal of the Belfast Base, and early in December the officer in charge rejoined the party, completing the work as far as Pretoria by December 23.

After a fortnight spent in refitting, work was begun on the Pretoria-Germiston section. It was, however, found necessary to abandon this section temporarily, owing to the fact that the railway line was being relaid, and accordingly the party moved on to Germiston and began work on the Potchefstroom section. Potchefstroom was reached on March 7, camp was again moved to Germiston, and a start was made on the Kroonstad section on March 18, there having been several days' delay owing to bad weather.

On May 9 the terminal of the Kroonstad Base was reached, and the equipment was sent by rail to Pretoria, where ten days were spent in refitting, preparatory to moving to Malelane to connect the gap left between that place and Machadodorp.

This portion of 105 miles was completed on July 16, and with the closing of the gap between Germiston and Irene, the field work of the party came to an end.

Camp was once more moved to Pretoria, and the party was disbanded on August 10.

The ground covered may be summarised as follows:—

	Miles.
Lourenço Marques–Malelane	88
Malelane–Machadodorp	105
Machadodorp–Balmoral	102
Balmoral–Pretoria	54
Pretoria–Germiston	36
Germiston–Kroonstad	126
Germiston–Potchefstroom	93
Connections to Base Terminals	7
	611

This total does not include repeated measures, or backward measures for check, &c., which would bring the total up to 630 miles.

The time occupied, including time spent in refitting and travelling, was almost exactly a year.

2. In addition to the determination of the heights above mean sea level of the terminals of the Belfast and Kroonstad bases, the heights of permanent bench marks, at an average distance of eight miles apart, were also determined. These bench marks, which are described elsewhere, were let into some permanent structure such as a station-building or the buttress of a bridge.

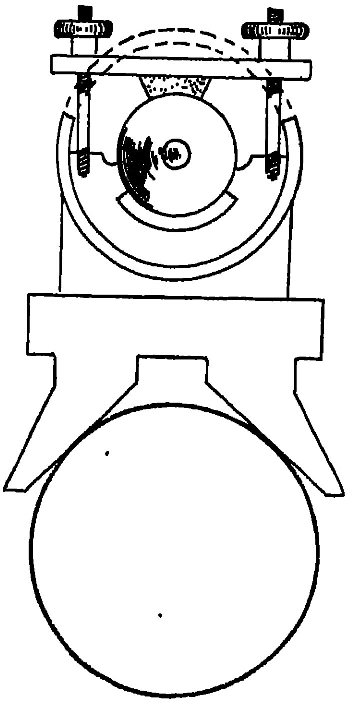
With the exception of two small deviations to the terminals of the base lines, the whole of the levelling was carried along the railway line. In one or two cases an attempt was made to cut across country, but in every case it was found that, owing to the nature of the ground, a loss of time resulted.

The experience gained in this work shows that the best route for the railway is also the best for the leveller, and that the railway also offers special facilities in the shape of permanent structures for the emplacement of bench marks.

Levelling Instrument.

3. The special features which distinguish this instrument from the ordinary engineer's level, are that the telescope can be rotated in its Y's, and the level reversed end for end. It is possible in this way to eliminate errors that would otherwise have had to be determined and allowed for.

The only unsatisfactory feature of the instrument was the mounting of the glass tube in the carrier. This tube was fixed into its brass mounting with plaster of Paris, and the expansions of brass, glass, and plaster of Paris being unequal, the result was that in the extreme heat to which the tubes were exposed in the summer, all the spare levels cracked, and it was necessary to order from the makers others so mounted as to allow for expansion.



By a curious coincidence, the original level in use on the instrument was the only one which did not crack, and in fact it lasted throughout the whole of the work, a very fortunate circumstance, as, for some time, there were no spare levels available.

NOTE.—An order was sent, in September, 1904, to the makers, Ponthus & Therrode, for new brass pieces which should take the glass tubes in such a way as to allow of their free expansion or contraction, and these became available in February, 1905. One of these is shown in the photograph of the instrument, Photos Nos. 7 and 8. The marginal sketch shews the mounting on a large scale.

4. The tripod is of the usual type, constructed of well-seasoned wood. A great convenience has, however, been introduced by making the top on which the instrument rests an adjustable one. It works on a spherical head (Photos 5 and 6), and can be placed approximately horizontal without the trouble of continually shifting the legs of the tripod. It also obviates the necessity of turning the levelling screws more than half a revolution.

5. The instrument is attached to the stand by a long screw projecting through the head of the tripod and fitting into the base of the instrument. This screw works against a spring in a socket below the head of the tripod, and allows sufficient elasticity to the connection to prevent a strain on the instrument.

The Levelling Staves.

6. The levelling staves, of which two pairs were used, are made of seasoned wood. Each staff consists of two pieces, each 3·2 m. long, and each with a graduated face. These may be clamped together in such a way as to form one staff of that length with two graduated faces, or the pieces may be packed face to face for transport.

One face, hereinafter called Face 1, is graduated to centimetres, the other, or Face 2, to an arbitrary scale which bears a ratio of 11:9 to the centimetre scale. The divisions are painted in black on a white ground, and are remarkably clear even at the maximum distance at which the staves were used.

A level let into each staff controls its verticality, while a handle fitted to each side of the staff, together with a stay as shown in Photo No. 15, ensure its steadiness.

One of the pieces of which the staff is composed is shod with iron, and during observation the staff is held on a steel pin with a spherical turned head. These pins are from 6 to 12 inches in length, according to the nature of the soil. A circular iron plate, perforated to receive the pin, rests on the ground. The head of the pin is driven home to this plate so that the vertical height of the pin is not affected by the superposed weight of the staff.

The Standardising Apparatus.

7. The standard used in determining the length of the staves consists of a brass scale let into a groove in the surface of a wooden frame. This brass scale is divided in the same way as Face 1 of the staves, to centimetres, and is of the same length, viz., 3·2 m.

The value of a division of this scale, however, changes appreciably with temperature. In order to reduce the value of a division to the temperature at which it is equal to the standard centimetre, a thin steel bar of the same length, and fixed in the same way, is added. This is graduated at its extremity with a very fine scale, and forms with the brass a metallic thermometer, by means of which the temperature can be obtained.

The two scales are fixed at one end to a bronze plate connected with a micrometer screw. This enables the observer to measure, in terms of this screw, the displacement of any division of the staff with respect to the corresponding division of the brass scale—in other words, its distance from the zero.

A specially adapted microscope, which fits on the frame carrying the metal scales, is used in making the observations.

Photos Nos. 22 and 28, show the arrangement of the standard and staff in making the comparison.

Comparison of Staves with Standard.

8. The following are the results of the comparisons of the Staves with the Standard. They were always compared immediately before being taken into the field, and again immediately on return, several comparisons being made at each epoch, the mean of which is given here :—

STAVES I. & II.

Date of Comparison.	Correction per Metre.			
	Staff I.		Staff II.	
	Face 1.	Face 2.	Face 1.	Face 2.
1904.	mm.	mm.	mm.	mm.
July 28	+ ·28	+ ·20	+ ·55	+ ·26
September 9	·80	·17	·57	·31
„ 10	·27	·24	·58	·80
„ 26	·82	·20	·60	·30
December 8	·29	·20	·53	·29
1905.				
January 18	·83	·24	·56	·32
March 27	·39	·28	·65	·40
„ 80	·41	·33	·65	·41
„ 81	·39	·84	·65	·38
May 15	·48	·35	·68	·37
„ 22	·40	·82	·64	·41
June 20	·29	·16	·49	·18
„ 26	·29	·23	·48	·33
July 8	·27	·21	·58	·32
August 18	·19	·11	·48	·25

STAVES III. & IV.

Date of Comparison.	Correction per Metre.			
	Staff III.		Staff IV.	
	Face 1.	Face 2.	Face 1.	Face 2.
1904.	mm.	mm.	mm.	mm.
July 28	+ ·45	+ ·18	+ ·52	+ ·84
August 29	·50	·20	·48	·35
December 1	·56	·18	·51	·35
1905.				
February 1	·58	·16	·50	·37
March 15	·53	·26	·58	·47
April 4	·58	·33	·56	·50
June 18	·57	·24	·58	·41
August 10	·48	·13	·42	·26
„ 18	·56	·13	·43	·29

9. There is scarcely sufficient time covered by the comparisons to form any very definite opinion as to the laws governing the changes of length. Broadly speaking, there seems to be two epochs, one from June to February, or a summer epoch, the other from February to June, or a winter period.

10. The very large change in Staves I. and II. between May 22 and June 20 occurred on the Malelane–Machadodorp section, and can only be explained as the effect of the climate of the low veld on the staves, which lengthened enormously. This was detected in the field reductions, and the other pair (III. and IV.) were sent for. An inspection of the figures given for the comparisons of June 13 and August 10 shows that the same change occurred in this pair of staves on being taken to the more humid climate of the Eastern part of the Colony.

Scale-Values. 11. The following are the Scale-values adopted for the different sections :—

STAVES I. & II.

Dates.	Sections.	Bench Marks.	Staff I.		Staff II.	
			Face 1.	Face 2.	Face 1.	Face 2.
			mm.	mm.	mm.	mm.
1904.						
Aug. 15–Sept. 6 ..	Lourenço Marques–Komati Poort	0 to 5	+ ·29	+ ·13	+ ·57	+ ·23
Sept. 28–Dec. 4 ..	Machadodorp–Balmoral	01 to 014	·30	·20	·56	·30
1905.						
Jan. 15–Mar 7 ..	Pretoria–Irene	24 to 26	·33	·24	·56	·32
	Germiston–Potchefstroom	32 to 48	·36	·26	·60	·36
Apr. 5–May 15 ..	Vereeniging–America siding	52 to 60	·40	·33	·61	·40
	America siding–E terminal, Kroonstad base ..	60 to E.E.B.	·43	·35	·68	·37
May 25–June 15 ..	Malelane–Alkmaar	9 to 13	·41 ·29	·34 ·16	·66 ·49	·39 ·18

STAVES III. & IV.

Dates.	Sections.	Bench Marks.	Staff III.		Staff IV.	
			Face 1.	Face 2.	Face 1.	Face 2.
			mm.	mm.	mm.	mm.
1904.						
Sept. 6–Sept. 22 ..	Komati Poort–Malelane	6 to 9	+ ·47	+ ·16	+ ·51	+ ·26
Dec. 5–Dec. 23 ..	Balmoral–Pretoria	014 to 024 024 to 25	·56	·18	·51	·35
1905.						
Mar. 18–Apr. 4 ..	Germiston–Vereeniging	32 to 52	·58 ·58	·26 ·35	·58 ·56	·44 ·52
June 15–Aug. 10 ..	Alkmaar–Machadodorp	13 to 01	·57	·24	·58	·41
	Germiston–Irene	32 to 26	·43	·13	·42	·26

NOTE.—Where two bracketed values are given, the adopted value for any day or group of days has been obtained by interpolation—generally week by week.

Methods of observation and computation of heights.

12. (*a*) During work in the field two staves, called respectively the backward and the forward staff, were used. The distance between them varied according to the gradient and the state of the atmosphere, the determining factor in the former being the necessity of having all three wires in the instrument projected on the staff.

(*b*) The distance of each staff from the instrument, which was placed exactly midway, was limited to 100 metres. Only in very exceptional cases was this limit materially exceeded.

(*c*) The actual observation of the difference of level between two points consisted in the reading of the three wires on both forward and backward staves in both positions of the instrument, the reading of the level for each reading on the staff being noted. This was done for both Face 1 and Face 2, so that each observation gave two determinations of the difference of level.

(*d*) An example of a typical observation is here given :—

Date 2.8.05, p.m.

Sight Number.	Staff.	Position of Instrument.	Readings on Staff.	Level Readings.	
				O*	E*
46 Back	3	1	(*a*) 1·425 4·735 3·025	0·5	0·8
		1	(*b*) 32·82 35·55 38·23	0·5	0·3
		2	(*c*) 32·84 35·53 38·25	0·9	—0·1
		2	(*d*) 1·44 4·73 8·07	0·9	—0·1
46 Forward	4	2	(*e*) 21·23 24·47 27·74	0·1	0·7
		2	(*f*) 49·08 51·68 54·38	0·1	0·7
		1	(*g*) 49·00 51·68 54·38	—0·5	1·35
		1	(*h*) 21·18 24·47 27·70	—0·5	1·35

* O=Object glass end; E=Eye-piece end.

(*e*) The data required for the reduction of the observations are :—

(1) The correction for scale-value of the staves.

(2) The distance from the instrument to the staff.

(3) The value of one division of level.

(*f*) The scale-value of the staves has already been dealt with. The following table, derived from observations made in July, 1904, gives the length in metres on the staff intercepted by the wires at various distances :—

Distance.	Interval intercepted on Staff.		
	Faces 1 and 2.	Face 1.	Face 2.
m.	m.	m.	m.
10	0·096	·048	·048
20	0·196	·099	·097
30	0·296	·149	·147
40	0·396	·199	·197
50	0·496	·249	·247
60	0·596	·300	·296
70	0·695	·350	·345
80	0·795	·400	·395
90	0·895	·450	·445
100	0·995	·501	·494
110	1·095	·551	·544
120	1·195	·601	·594

These figures show that, for all practical purposes, the distance may be taken as one metre for every centimetre intercepted between the extreme wires, or for every fifty millimetres intercepted between the centre and either of the outside wires.

(*g*) Four determinations were made of the value of one division of level, as follows :—

1904, June	... ...	29·0
1905, January	... ...	28·5
„ March	... ...	27·0
„ May...	... ...	26·8

The determination of June, 1904, was used from the start at Lourenço Marques till March 7, 1905, after which the value derived from the observation of March, 1905, was adopted. The following table gives the corrections for level, in terms of the units of the two faces of the staves :—

Distance.	1 Division of Level = 29″		1 Division of Level = 27″	
	Face 1.	Face 2.	Face 1.	Face 2.
m.	mm.	mm.	mm.	mm.
10	·014	·012	·013	·011
20	·028	·023	·026	·022
30	·042	·035	·039	·032
40	·056	·046	·052	·043
50	·070	·058	·066	·054
60	·085	·069	·079	·065
70	·099	·081	·092	·076
80	·113	·092	·105	·086
90	·127	·103	·118	·097
100	·141	·115	·131	·108

As the corrections for level were always kept as small as possible, and as, over a long series, these corrections would certainly tend to eliminate each other, practically no difference would be introduced by using a progressive change in the level values. The corrections have therefore been applied as above stated.

(*h*) With the data given in paragraphs 11 and 12 (*f* and *g*), it is now possible to give an example of the reduction of the observation quoted in paragraph 12 (*d*). The reduction is effected as follows :—

$$\text{Distance of staff} = \begin{cases} 66 \text{ B} \\ 65 \text{ F} \end{cases}$$

	Means of Readings.		Corrections for level.	Corrections for Scale-value.
	dm.	dm.	div.	dm.
(*a*)	4·728	4·738 (*k*)	−0·30	+0·002
(*d*)	·747			
(*b*)	35·533	35·537 (*l*)	−0·30	+0·001
(*c*)	·540			
(*e*)	24·480	24·465 (*m*)	+0·61	+0·011
(*h*)	·450			
(*f*)	51·697	51·684 (*n*)	+0·61	+0·008
(*g*)	·670			

Face 1.

dm.

(*m*) − (*k*) = +19·727

+0·91 × 0·087 = + ·079

Scale value + ·009

+19·815

F_1 = +19·815

Face 2.

dm.

(*n*) − (*l*) = +16·147

+0 91 × 0·071 = + ·065

+16·212

+19·814*

Scale value + ·007

F_2 = +19·821

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* 16·212 multiplied by 1·2222, the ratio of F_2 to the metre scale.

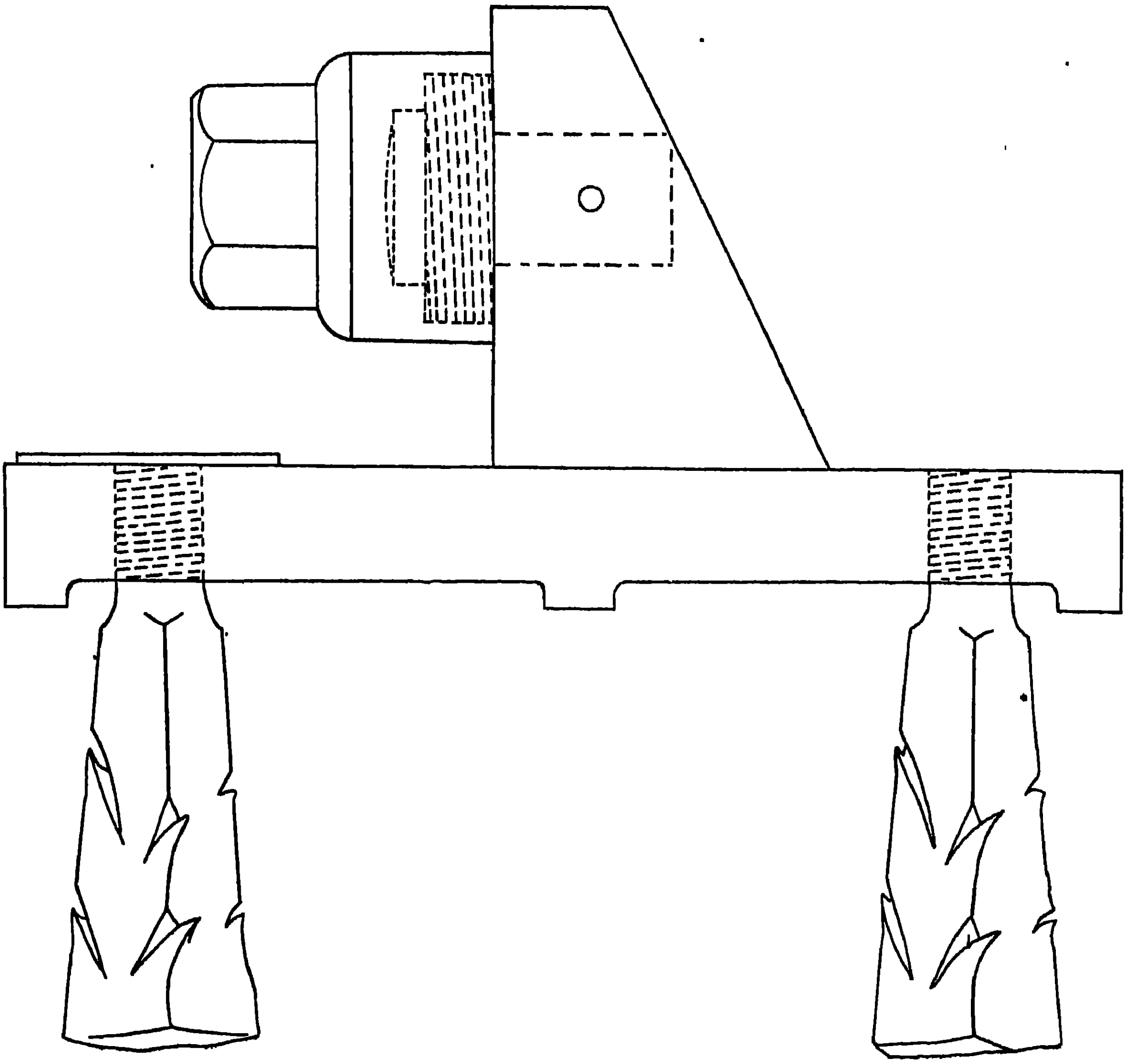


Fig. 1.—Upright Bench Mark.

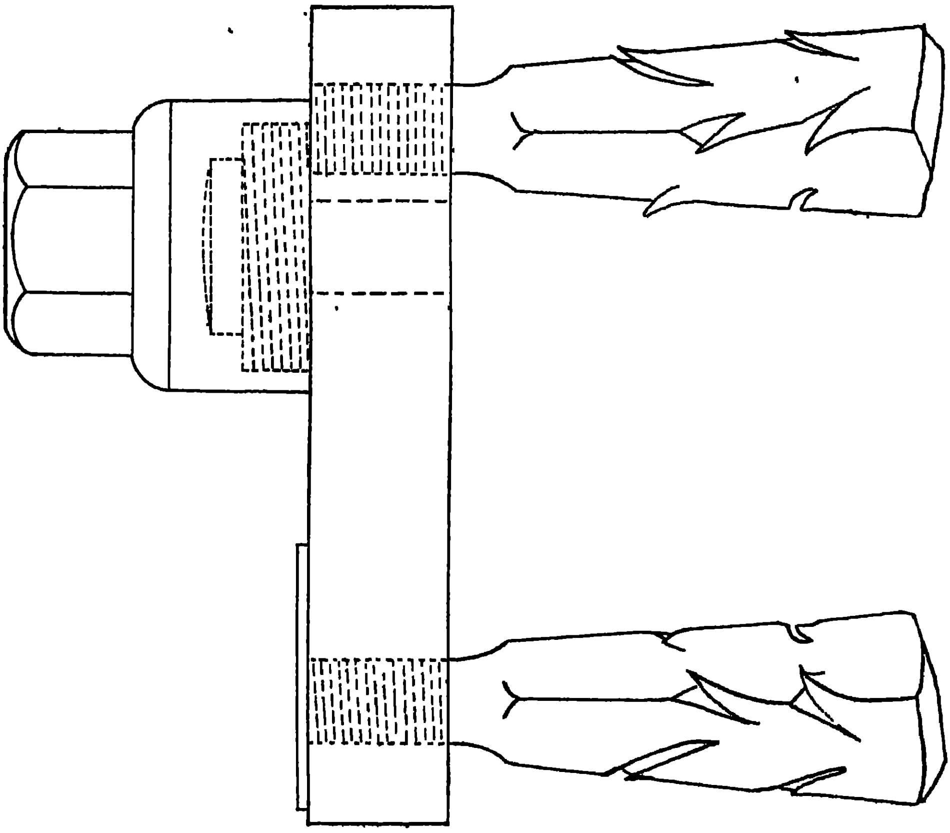


Fig. 2.—Flat Bench Mark.

BENCH MARKS.

13. Figures 1 and 2 show the types of Bench Mark used. These were emplaced at an average distance of eight miles apart in convenient permanent structures, such as Stationhouses, Buttresses of Bridges, or Culverts.

The following is a complete list of the Bench Marks so emplaced :—

SECTION : LOURENÇO MARQUES TO PRETORIA.

Bench Mark.	Height above Mean Sea Level.	Where Placed. (E. = Eastern or Lourenço Marques end of line or portion of line; W. = Western or Pretoria end; N. or S. = Northern or Southern side with respect to above E. or W.; B.M. = Bench Mark; M.P. = Mile post or posts.)
	Eng. ft.	
0	15·9	In power-house on wharf opposite to W. end of Lourenço Marques railway station. (This bench mark has subsequently been damaged, and is now of no use.)
1	103·3	Machava station, kilo. 10·4. Upright B.M. in front wall, facing line, near E. corner of the old Machava station, N. side of disused line. This Station is ± ½-kilo. N. of the new station of the same name.
2	306·7	Pessene station, kilo. 38. Upright B.M. in W. wall of stone building—the W. of two buildings.
3	339·3	Large bridge near kilo. 72. Flat B.M. on top of E. abutment, N. side of line.
4	394·3	Ressano Garcia station, kilo. 87. Upright B.M. under steps in W. wall of signal cabin, S. of line and opposite to the railway station.
5	421·7	Large Bridge over Komati River, about ½-mile E. of Komati Poort station. Flat B.M., S. of line, on top of first pier from W. abutment.
6	734·3	Tenbosch station, N. side of line. Upright B.M. in wall of railway station, S.E. corner.
7	950·0	Oorsprong station, S. side of line. Upright B.M. in E. wall of station, near N.E. corner.
8	879·4	Hector-spruit station, N. side of line. Upright B.M. near S.E. corner in E. wall of ganger's cottage, No. 408, close to and W. of railway station.
9	1004·2	Bridge No. 25, about ¼-mile E. of Malelane station. Flat B.M. on top of W. abutment, N. side of line.
10	1039·0	Bridge No. 38, near 97½ M.P., about 1¼ miles W. of Rockvale. Upright B.M. in E. abutment, N. side of line.
11	1286·1	Bridge No. 57, at 106 M.P., near Ross siding. Flat B.M. on top of W. abutment, S. side of line.
12	1675·2	Bridge No. 82, near 118¾ M.P., about 1 mile W. of Crocodile Poort station. Upright B.M. in W. abutment, S. side of line.
13	1829·1	Bridge No. 92, between 120 and 120¼ M.P., 1¾ miles E. of Mayfair. Flat B.M. on top of E. abutment.
14	2164·7	Bridge No. 98, between 126¼ and 126¾ M.P., about ½-mile E. of Nelspruit station. Upright B.M. in E. abutment, S. side of line.
15	2230·9	Bridge No. 106, near 133¾ M.P., about ¾-mile W. of Cairn. Upright B.M. in W. abutment, S. side of line.
16	2424·1	Bridge No. 116, near 142½ M.P., about 3¾ miles E. of Alkmaar. Upright B.M. in E. abutment, S. side of line.
17	2757·3	Bridge No. 136, near 152½ M.P., about ½-mile E. of Elandshoek. Upright B.M. in W. abutment, S. of line.
18	2968·0	Bridge No. 144, over Godwan River, near 160 M.P. Flat B.M. on top of W. abutment, N. side of line.

BENCH MARKS—*continued.*

Section : Lourenço Marques to Pretoria—*continued.*

Bench Mark.	Height above Mean Sea Level.	Where Placed.
	Eng. ft.	
19	3414·7	Bridge No. 155, between 169¾ and 170 M.P., about 1 mile E. of Airlie. Flat B.M. on top of E. abutment, S. side of line.
20	3688·6	Bridge No. 168, near Sycamore siding, at 176¼ M.P. Flat B.M. on top of W. abutment, S. side of line.
21	3919·5	Bridge No. 166 (Western of two bridges), near 180¼ M.P. Upright B.M. in E. abutment, N. side of line.
22	4385·1	In wall at entrance to tunnel between Waterval Boven and Waterval Onder. Upright B.M. in E. face of wall, N. side of line.
23	4422·2	In wall at entrance to tunnel between Waterval Boven and Waterval Onder. Upright B.M. in W. face of wall, N. side of line.
24	4781·0	Bridge at 188¼ M.P., about 2¾ miles W. of Waterval Boven. Upright B.M. in W. abutment, N. side of line.
01	5115·9	Machadodorp station, N. of line. Upright B.M. in wall of station, facing line.
02	5796·1	Culvert at 202¾ M.P., about ¾-mile E. of Dalmanutha station. Flat B.M. on top of culvert, S. side of line.
03	6307·1	Belfast station, N. side of line. Upright B.M. at back of station near N.W. corner of wall, facing Belfast.
04	6107·1	Ganger's cottage, No. 440, N. side of line, near 221¼ M.P., about 5 miles E. of Wonderfontein. Upright B.M. in W. wall of cottage.
05	5644·9	Culvert at 230¼ M.P., about 3½ miles E. of Arnott. Flat B.M. on top of culvert, S. side of line.
06	5278·7	Bridge No. 184, near 237½ M.P., about 2½ miles E. of Pan. Flat B.M. on top of E. abutment, N. side of line.
07	5130·4	Culvert No. 188, near 245¾ M.P., about 1½ miles E. of Derwent. Upright B.M. low down on S. side of culvert.
08	4815·3	Middelburg station, N. side of line. Upright B.M. in W. wall of station, near restaurant.
09	5061·4	Culvert between 262 and 262¼ M.P., about 1¾ miles E. of Hillside. Flat B.M. on top of culvert, S. side of line.
010	4713·4	Great Olifants River station, S. side of line. Upright B.M. in E. wall of station, near S.E. corner.
011	5164·4	Witbank station, N. side of line. Upright B.M. in W. wall of station.
012	4989·7	Culvert at 286¾ M.P., near and E. of Wakefield. Flat B.M. on top of culvert, S. side of line.
013	4758·2	Balmoral station, S. side of line. Upright B.M., level with ground, in E. foundation of signal box near N.E. corner of station.
014	4715·7	Culvert No. 206 at 297¼ M.P., W. of and near ganger's cottage No. 454, about 3 miles W. of Crown Douglas siding. Flat B.M. on top of culvert, S. side of line.
015	4504·5	Bridge No. 208, between 303¼ and 303¾ M.P., about 2 miles W. of Wilge River station. Upright B.M. in E. abutment, S. side of line.
016	4520·5	Bridge No. 211, E. of and near Bronkhorstspruit station. Upright B.M. in W. abutment, N. side of line.

BENCH MARKS—*continued.*

Section: Lourenço Marques to Pretoria.

Bench Mark.	Height above Mean Sea Level.	Where Placed.
017	Eng. ft. 4781·4	Percydale siding, N. side of line. Upright B.M. in E. wall of No. 2 cottage—the E. of two cottages.
018	4768·2	Bridge No. 214, near 321½ M.P., about 1½ miles W. of Elands River station. Upright B.M. in W. abutment, S. side of line.
019	4686·7	Bridge No. 217, near 326¼ M.P., about ¾-mile E. of Van der Merwe station. Upright B.M. in E. abutment, S. side of line.
020	4420·3	Bridge No. 220, between 330½ and 330¾ M.P., about 1¾ miles E. of Pienaars Poort. Upright B.M. in E. abutment, S. side of line.
021	4290·5	Bridge No. 228, near 335½ M.P., about 1¼ miles E. of Hatherley. Upright B.M. in W. abutment, N. side of line.
022	4255·1	Bridge No. 225, near and E. of Silverton siding, 340¾ M.P. Upright B.M. in W. abutment, N. side of line.
023	4344·7	Culvert No. 227 in Koedoespoort, about ½-mile W. of Koedoespoort station. Upright B.M. in E. abutment, S. side of line.
024	4425·7	Bridge No. 238 on Delagoa Bay line, near junction of Johannesburg line, close to Pretoria station. Upright B.M. in E. abutment, S. side of line.
25	4343·9	Government Buildings, opposite Grand Hotel, Market Street, Pretoria. Upright B.M., protected by iron box, in E. wall near N.E. corner.

SECTION: PRETORIA TO GERMISTON.

Bench Marks.	Height above Mean Sea Level.	Where Placed. (N. = Northern or Pretoria end of line or portion; S. = Southern or Germiston end of line or portion.)
26	Eng. ft. 4721·0	Irene Bridge, S. of Irene station, near 359¼ M.P., Upright B.M. in S. abutment, W. side of line.
27	4802·2	Culvert at 361½ M.P., about ½-mile S. of Pinedene station. Flat B.M. on top of culvert, W. side of line.
28	5026 5	Culvert near 365 M.P., about ¼-mile S. of Olifantsfontein station. Upright B.M. on E. side of culvert.
29	5264·1	Culvert near 368¾ M.P., about 2 miles S. of Oakmoor. Flat B.M. on top of culvert, W. side of line.
30	5288·2	Bridge near 373½ M.P., about ¾-mile S. of Birchleigh. Flat B.M. in N. abutment, E. side of line.
31	5555·9	Culvert at 380¼ M.P., near to and N. of Rietfontein. Upright B.M. on W. side of small culvert.

BENCH MARKS—*continued.*

SECTION: GERMISTON TO POTCHEFSTROOM.

Bench Marks.	Height above Mean Sea Level.	Where Placed. E. = Eastern or Germiston end of line or portion; W. = Western or Potchefstroom end of line or portion.
	Eng. ft.	
32	5462·8	Bridge over mine line, about ¼-mile E. of Driehoek station. Flat B.M. on top of W. abutment, N. of lines.
33	5700·0	Park station. Upright B.M. in E. wall near S.E. corner of lavatory on Park station platform, between up and down lines.
34	5621·1	Culvert at 11¾ M.P., about ¾-mile E. of Langlaagte station. Upright B.M. on S. side of culvert.
35	5568·4	Culvert about 280 yds. W. of 16½ M.P., ⅜-mile W. of Maraisburg station. Upright B.M. on S. side of small culvert near to road crossing line to W.
36	5751·9	Culvert about 80 yds. W. of 28½ M.P. Upright B.M. between up and down lines, in W. wall. (This culvert has subsequently been covered over, so that the B.M. is not accessible.)
37	5683·0	Culvert No. 24 at 29½ M.P., about ½-mile W. of Krugersdorp station. Upright B.M. on N. side of Potchefstroom line. (A portion of the Zeerust line has since been laid alongside the Potchefstroom line, and the B.M. is now buried under the Zeerust line.)
38	5618·3	Culvert halfway between 35¾ and 36 M.P., ⅝-mile E. of Randfontein station. Upright B.M. on S. side of culvert.
39	5457·2	Culvert about 100 yards W. of 40¾ M.P., about 4¼ miles W. of Randfontein station. Upright B.M. on N. side of culvert.
40	5224·2	Bridge No. 27, near 45¾ M.P., between Randfontein (36½) and Bank (53¼ m.) stations. Flat B.M. on first pier from W. abutment, N. side of line.
41	4994·9	Bridge No. 29, between 52¼ and 52½ M.P., about ½-mile E. of Bank station. Flat B.M. on top of middle pier, S. side of line.
42	4912·9	Culvert about 150 yds. W. of 61¾ M.P., ¾-mile W. of Oberholzer siding. Upright B.M. on S. side of culvert.
43	4831·9	Bridge No. 30, between 69 and 69¼ M.P., about 1 mile W of Welverdiend. Upright B.M. in E. abutment, S. side of line.
44	4676·5	Bridge No. 31 at 80¾ M.P., ½-mile E. of Frederickstad station. Upright B.M. in E. abutment, N. side of line.
45	4593·4	Bridge No. 33, about 150 yds. E. of 86½ M.P., ¾-mile W. of Boskop. Upright B.M. in E. abutment, N. side of line.
46	4495·1	Culvert No. 34, about 150 yds. E. of 91¼ M.P., 5½ miles W. of Boskop. Upright B.M. on S. side of culvert.
47	4438·8	Bridge No. 36, near 93 M.P., 3¾ miles E. of Potchefstroom station. Flat B.M. on first pier from E. abutment, N. side of line.

BENCH MARKS—*continued.*

SECTION: GERMISTON TO KROONSTAD.

Bench Mark.	Height above Mean Sea Level.	Where Placed. (N. = Northern or Germiston end of line or portion; S. = Southern or Kroonstad end of line or portion.)
	Eng. ft.	
48	5409·2	Bridge about 150 yards S. of 702 M.P., about 3 miles S. of Germiston Station. Upright B.M. on S. abutment, between up and down lines.
49	5062·1	Bridge between 693¾ and 694 M.P., ½-mile N. of Natal Spruit Station. Flat B.M. on S. abutment, E. side of line.
50	4869·0	Bridge about 50 yards N. of 684½ M.P., ½-mile N. of Klip River Station. Upright B.M. on S. abutment, E. side of line.
51	4887·5	Bridge about 100 yards N. of 674 M.P., 1 mile N. of Meyerton Station. Upright B.M. on E. side of line, in E. wall of parapet of N. abutment.
52	4709·3	Vaal River Bridge, S. of Vereeniging. Flat B.M. on top of parapet on N. abutment, E. side of line.
53	4683·9	Bridge over Taaibosch Spruit at 654½ M.P., 4¼ miles S. of Viljoensdrift Station. Flat B.M. on top of first pier from N. abutment, E. side of line.
54	4852·7	Bridge halfway between 647 and 647¼ M.P., 3 miles N. of Wolvehoek Station. Upright B.M. in S. abutment, E. side of line.
55	4809·8	Bridge between 638½ and 638¾ M.P., about halfway between Wolvehoek and Dover Stations. Upright B.M. on W. side of line in W. end of pier.
56	4862·3	Water-tank house at Vredefort Station, near 627½ M.P., W. side of line. Upright B.M. in E. wall.
57	4608·2	Bridge near 619 M.P., 1½ miles S. of Lion River Siding. Flat B.M., E. side of line, on top of first pier from S.
58	4519·8	Bridge over Rhenoster River, at pumping station, halfway between 613½ and 613¾ M.P. Upright B.M. in S. abutment, E. side of line.
59	4718·6	Culvert halfway between 602½ and 602¾ M.P., about 2 miles S. of Serfontein Siding. Upright B.M. in N. wall, E. side of line.
60	4564·0	Bridge about 50 yards N. of 599 M.P., ½-mile N. of Honing Spruit Station. Upright B.M. facing N., on W. side of line, in first pier from S.
61	4581·3	Bridge about 50 yards S. of 591¾ M.P., 1½ miles N. of America Siding—the middle of three bridges or culverts, close together and all between 591½ and 591¾ M.P. Upright B.M. on W. side of line, in W. end of pier.
62	4624·0	Culvert 100 yards S. of 581½ M.P., 3¾ miles N. of Kroonstad Station. Upright B.M. in S. wall, W. side of line.

V. A. LOWINGER.

REPORT OF MR. P. C. MORGENROOD ON THE WORK OF THE CENTRAL OFFICE AND THE EXPENDITURE ON THE SURVEY.

Central Office.

1. The Central Office, established with a view to reducing delays to a minimum, was opened about six months after the reconnaissance and other parties had taken the field. From that date all reports, communications, requisitions, &c., passed through the central office, which controlled the finance of the field parties, the purchase and issue of animals, stores, transport, &c., &c.

Cost of Survey Detailed.

2. The actual cost of the Survey is as follows :—

EXPENDITURE.

	£	s.	d.	£	s.	d.
TRANSPORT, EQUIPMENT, AND EXPENSES :—						
Animals—						
Mules	4,126	16	0			
Horses	731	15	0			
Fodder	5,705	12	1			
Shoeing...	702	4	0			
Veterinary and Sundries ...	269	11	7			
				11,535	18	8
Harness, Saddlery, &c.—						
Harness...	507	10	3			
Saddles, saddlebags, bridles, &c.	157	5	3			
Halters, neckstraps, nosebags, &c.	343	1	6			
Horse-rugs, &c.	325	2	8			
Repairs, &c.	531	12	6			
				1,864	12	2
Vehicles and Equipment—						
Wagons and trollies	383	0	0			
Carts	1,003	10	1			
Buck-sails, &c.	138	15	6			
Other equipment	92	2	0			
Repairs, &c.	534	4	0			
				2,151	12	7
Hired Transport, &c.				806	5	4
Railage (passenger and goods) ...				2,750	5	4
INSTRUMENTS AND EXPENSES				2,838	5	8
EQUIPMENT :—						
Bar comparison shed	165	0	0			
Portable bar and theodolite huts, &c.	561	18	3			
Theodolite stands, complete ...	142	12	0			
„ carrying straps and poles	16	8	6			
Pulley equipment and straining-posts	94	18	6			
Meridian marks, lamps, cases, &c. ...	76	7	1			
Miscellaneous	80	7	7			
Beacons and beaconing accessories...	841	13	9			
Bench marks and appliances ...	246	7	6			
Mallets, flag-staves, cement, &c. ...	144	12	10			
				2,370	6	0
Carried forward				24,317	5	9

	£	s.	d.	£	s.	d.
Brought forward … …				24,317	5	9
TENTS, TOOLS, AND CAMP EQUIPMENT, &c. :—						
Tents and equipment … …	961	17	3			
Camp tables, stretchers, &c. …	89	2	4			
Cooking shelter and latrines …	78	4	6			
„ utensils, &c. … …	96	18	0			
Boxes, trunks, &c … … …	71	19	1			
Carpenters', masons', and labourers' tools … … … …	122	13	0			
Water-vaatjes, barrels, &c.… …	32	11	0			
Fencing wire, &c. … … …	40	17	4			
Miscellaneous … … …	175	11	3			
Maintenance… … … …	272	3	1			
				1,941	16	10
RENTS, TAXES, INSURANCES, &c. …				846	14	1
OFFICE FURNITURE AND FITTINGS …				253	3	9
STATIONERY, BOOKS, MAPS, MAINTENANCE, &c. … … … …				374	12	11
SALARIES … … .. … …				41,235	1	1
TRAVELLING ALLOWANCES … …				853	17	6
NATIVE PAY, FOOD, BLANKETS, &c. …				7,067	5	10
SUNDRIES … … … … …				782	15	11
TOTAL EXPENDITURE … …				£77,672	13	8
SALES AND REFUNDS :— *Less* amounts realised by the sale of animals, transport, stores, &c., and refunds from all sources … … … … … …				5,955	9	10
				£71,717	3	10
VALUATION :— To arrive at as near an estimate as possible of the net cost of the survey, the base apparatus, Jaderin apparatus, chronometers, theodolites, and other instruments and appliances, which may be required by Government, have been taken at a valuation amounting to … …				2,555	17	5
NET COST OF THE TRIGONOMETRICAL SURVEY …				£69,161	6	5

Summary cost.

3. The cost of the field parties (to each of which has been charged the proportionate share of depreciation of instruments, &c.) and of headquarters—in the latter is included the computing and reduction work, standardising of the measuring bars, and the cost of erecting a special shed for the bar apparatus—is as follows :—

	£	s.	d.
Headquarters, computing, &c. … … …	19,711	11	9
Base line … … … … … …	9,526	17	10
Reconnaissance … … … … …	8,908	19	8
Beaconing and beacons … … .. …	5,056	4	8
Observing … … … … …	22,849	18	1
Geodetic levelling … … … …	3,107	14	5
	£69,161	6	5

For details of the foregoing, *see* Report by Mr. S. B. Morgenrood on Comparative Costs of Sections of the Survey, Table I. The amounts given at the foot of each column have been reduced proportionately for the valuation of stores remaining on hand and the Basutoland contribution to the survey, amounting in all to £5,555 17*s.* 5*d.* The amount in the column for "subsidiary and secondary triangulation" has been added to that of "observing." The two columns of "reconnaissances" have been added together.

Transport animals and casualties.

4. In taking into account the high prices paid for animals, fodder, &c., it must be remembered that when the Survey was started at the end of 1902 the country was practically in ruins. The bulk of the animals, fodder, &c., was obtained in the early days from the Transvaal Repatriation Department.

The average price paid per head for animals is as follows:—

Mules.

		£	s.	d.
133	from Transvaal Repatriation Department, average	29	18	11
7	" other sources ... ... "	20	11	5
140				

Horses.

		£	s.	d.
14	from Transvaal Repatriation Department, average	22	14	3
15	" other sources .. .. "	27	11	8
29				

From the above it will be seen that 140 mules and 29 horses were bought. Of these, 23 mules, or $16\frac{3}{7}$ per cent., and 10 horses, or $34\frac{3}{4}$ per cent., died of disease or were shot. The remaining 117 mules and 19 horses were, from time to time, disposed of, the bulk being taken over by the Public Works Department. The total realised from the sale of these animals is £2,184.

Subjoined is a list giving cause of death and reason why shot:—

Mules.

		Number.
1903.		
Jan.	*.—Kicked on jaw and could not eat. Veterinary surgeon could do nothing. Shot by order of Superintendent, Trigonometrical Survey... ...	1
Apr.	7.—Horse sickness contracted in Komati Valley. Died at Lakenvlei, near Belfast	1
June	6.—Windy colic. Died near Witbank, district Middelburg...	1
Aug.	15.—Colic. Died at Lakenvlei	1
1904.		
Jan.	14.—Broke leg in camp near Pretoria. Shot by order of Superintendent	1
"	12.—Chronic lameness. Shot at Wepener	1
"	20.—Dik-kop. Died near Olifants river	2
"	21.—Horse sickness. Died in Kaap Valley	2
Feb.	*.—Dik-kop. Died at Nooitgedacht, district Krugersdorp...	1
Mar.	*.—Injured by kick. Shot by order of District Commandant, Ermelo	1
Apr.	22.—Inflammation of the bladder. Died in Pretoria Camp	1
May	*.—Dik-kop. Died at Houts River, Zoutspansberg ...	1
Oct.	1.—Dik-kop. Died at Machadodorp	1
	Carried forward	15

* Date not recorded.

	Number.	
Brought forward	15	
1905.		
Jan. 30.—Inflammation of the stomach. Died near Christiana	1	
May * .—Broken leg. Shot near Klerksdorp	1	
May 21.—Eating poisonous plants. Died near Kimberley ...	1	
July 24.—Dik-kop. Died at Pont Drift, Zoutpansberg ...	1	
Aug. 13.—Colic. Died at Woodbush, Zoutpansberg	1	
„ 24.—Worn out. Could not rise. Shot near Mara, Zoutpansberg, by order of Mr. Simms	1	
„ 26.—Sick mule, left at Gelukfontein, near Lace Mines Station, O.R.C., for treatment, died	1	
Sept. 22.—Developing glanders (?) Shot by order of Veterinary Department...	1	
Total (mules)		23

Horses.

1903.		
Feb. 3.—Horse sickness. Died in camp near Pretoria ...	1	
„ 14.—Horse sickness. Died in camp near Pretoria ...	1	
„ * —Horse sickness. Died near Ermelo	1	
Nov. 18.—Eating poisonous plants. Died near Olifants River...	1	
1904.		
Jan. 21.—Peritonitis. Shot by S.A.C., near Bothaville, O.R.C.	1	
Mar. 25.—Horse sickness. Died near Maré's Kop, District Lydenburg	1	
May 11.—Colic. Died near Belfast	1	
Oct. 5.—Dunkop. Died near Machadodorp	1	
1905.		
June 4.—Colic. Died between Crocodilpoort and Nelspruit ...	1	
Sept. 19.—Mallein test unsatisfactory. Destroyed by P.W. Department on order of Veterinary Department	1	
Total (horses)		10
Total mules and horses dead ...		33

Stock lists.

5. Particulars of the stock list that was found most practicable are given below. The stores, transport, &c., were divided under the following heads, and separate pages of detailed lists allotted to each, as follows :—

Animals.

Books (other than account, manifold, and field note books).

Camp equipment.

Harness, saddlery and equipment.

Instruments.

Kitchen utensils.

Tools (carpenters, masons, and native labourers).

Wagons, carts, and equipment.

Under each head were ten columns. Subjoined will be found the headings of these and the instructions there anent.

---

* Date not recorded.

1	2	3						4
List of	Stock on hand last stock-taking ......190 .	........Added during the month of						Total of columns 2 and 3.
		January.	February.	March.	April.	May.	June.	
(Details)								

5						6	7	8	9
........Deducted during the Month of						Total deductions as per column 5.	Difference between columns 4 and 6.	Stock on hand ..190 .	Deficient. (Difference between columns 7 and 8.)
January.	February.	March.	April.	May.	June.				

Column 10

Explanatory Notes on the Items struck off Charge, Deficiencies, &c.

a	
b	

Instructions as regards taking stock.

6. Stock must be taken every six months (on or about 30th June and 31st December), a new list opened, and the old one sent registered to Headquarters with the columns duly filled in and the pages signed by the officer in charge. FOR THE PURPOSE OF TAKING STOCK ALL OTHER WORK MUST STOP FOR THE TIME BEING.

Each auxiliary party should have a stock list which is to be signed by the person in charge.

Column 1. Add anything not already on the list.

„ 2. New parties should make a complete list of stock received when equipped and enter in this column. Old parties should bring over figures from column 8 of previous stock list.

„ 3. In this column enter every item of stock purchased or received from Headquarters after column 2 was made up. Stock transferred in the field from one party to another should be treated by the one as having been returned to and by the other as having been received from Headquarters. Each party should give notice to Headquarters of such transfer. On no account should transfers be made to parties working in other Colonies.

„ 4. Add the figures on each line in columns 2 and 3, and extend.

Column 5. Any stock worn out, or broken, and struck off charge, or returned to Headquarters, should be entered in the column for the month and a note made in column 10 giving reason why struck off charge. The letter of such explanatory note should be given against the number of articles struck off, thus 3*a*, 1*b*, 2*n*, 5*ac*, as the case may be.

„ 6. In this column given the totals of deductions made in column 5.

„ 7. Subtract the totals in column 6 from those in column 4 and enter in this column, which then represents what stock should be on hand.

„ 8. Enter stock on hand when taking stock.

„ 9. If any difference in figures in columns 7 and 8 enter such difference in this column and account for same in column 10.

„ 10. In this column deficiencies are to be accounted for and reason given why items were struck off charge.

Expendible articles, such as forage, oats, mealies, meal, flour, soap, dubbing, &c., need not be included in the stock list, nor need riems, curry combs, dandy and horse brushes be brought up.

Official Routine.

7 (*a*) For the information and assistance of those in charge of the books, letters, &c., on the completion of the Survey, a few details in connection with the office routine are introduced in this portion of the report.

(*b*) The expenditure in connection with the Trigonometrical Survey commenced in October, 1902, and all advances for expenditure during the financial year, ending 30th June, 1903, were accounted for to the Surveyor-General, Pretoria. Subsequently, this was done, first through the Accounting Officer, High Commissioner's Office, and later through the Secretary, Inter-Colonial Council, with consequent differences in instructions.

(*c*) The Central Office was opened towards the end of June, 1903. Shortly afterwards, instructions were received to keep certain routine books. These were kept in accordance with the instructions contained in the Government Circulars on the subject; but, previous to that, certain simplified books had been commenced, and were continued, as they appeared to be more suitable than the routine books.

(*d*) The circulars contained no specific instructions relating to the keeping of stock-books, and as this was considered a most important matter, stock-books were opened, but, owing to the long start the Survey had had, and the parties being scattered and difficult to communicate with, and, generally, the office having to be got in order while current matters had to be attended to, their adoption was considerably handicapped and progress in that direction was slow. To enable the stock, &c., already issued to be traced, and to keep a check on that in the possession of the field parties, printed detailed lists were issued to each party, with instructions to take stock on a certain date, and to return one signed list to the Central Office. These lists did not answer, and another (as fully detailed at the end of Part I.) was drafted and substituted. In passing, it may be remarked that had the stock been kept as subsequently desired by the Audit Department, about £2,000 would have been expended in salary to a special storekeeper, rent of store-room, delays to parties, &c.

(*e*) Full details of every item of expenditure will be found in the monthly expenditure books, from which the items relating to stock were taken and written up in a book marked "Stock-book," and afterwards posted in a ledger, the index to which is divided into the following headings:—

(1) Office.
(2) Instruments.
(3) Tools, &c.
(4) Animals.
(5) Wagons, carts and equipment
(6) Harness, Saddlery, &c.
(7) Camp Equipment.
(8) Kitchen Utensils, &c.

(*f*) With reference to letters and reports, the simplest methods were followed. Those received were entered in a Government Correspondence Register (in connection with which an index was kept) and numbered consecutively. When attended to, the letters were placed in letter files, of which there were two for each party (one for reports and another for correspondence), one for general correspondence, and one or more each for letters from H.M. Astronomer, Colonial Secretary's Office, Inter-Colonial Council, and Crown Agents. In the files containing letters from Colonial Secretary and Inter-Colonial Council and reports from parties will be found a list of their contents arranged according to registration numbers. In the files marked "Crown Agents' Vouchers," all papers relating to any one requisition will be found in the covers to which they belong. Crown Agents' file No. II. contains all the indents and papers relating to stores ordered for the Topographic and Geodetic Survey.

(*g*) With reference to letters despatched, those signed by the Superintendent will be found copied in the letter books, but the duplicates of general correspondence carried on by the Chief Clerk with field parties, shipping agents, storekeepers and others, will be found in the manifold letter books, all of which have been indexed. The numbers in red or blue in the top left-hand corners of each page show the preceding or next following letter, if any, addressed to the same person, in that book, whether manifold or ordinary letter book. In each letter book will be found a list giving contents of letters addressed to the Secretary, Inter-Colonial Council, and also their folio numbers.

(*h*) Letters *re* stores, animals, &c., taken over by the Public Works Department, or sold by auction in Pretoria, will be found copied in the letter books; and those relating to animals sold by auction through field parties will be found in the files of the respective field parties, where also will be found letters reporting deaths of animals, &c.

(*j*) All auctioneers' account sales and public works vouchers were filed with the monthly statements sent to the Secretary, Inter-Colonial Council, to whom, too, will be handed the receipts for instruments, &c., surrendered.

(*k*) Except in a few instances, when given direct by the Superintendent, all orders for goods bought on credit were in writing, the duplicates of which will be found in the order books. This does not refer to field parties.

(*l*) A few rail-warrants were not returned by the officers in charge of field parties, who carried such warrants in their pockets where they became worn-out and unserviceable and were destroyed. The correspondence on the subject will be found in the red letter file for general correspondence from 1st July, 1906 to 30th April, 1907.

List of books, files, &c.

8. A list of the above-referred-to books, files, &c., each duly numbered, is attached hereto.

RED LETTER FILES.

301	A. Simms	Reports.
302	,, ...	Correspondence.
303	Capt. Gordon	Reports.
304	,, ...	Correspondence.
305	Capt. Ley	Reports.
306	,, ...	Correspondence.
307	Lieut. King	Reports.
308	,, ...	Correspondence.
309	Lieut. Dunman	Reports.
310	,, ...	Correspondence.
311	V. A. Lowinger	Reports and correspondence.
312	S. B. Morgenrood	Reports.
313	,, ...	Correspondence.
314	J. F. Gill	Reports.
315	,, ...	Correspondence.
316	C. Middleton	Reports.
317	,, ...	Correspondence.

318 G. E. Ezzey ... ... Reports and correspondence.
319 Colonel Morris ... ... Correspondence.
320 Applications for employment.
321 Letters before 30th June, 1903.
322 ,, ,, ,,
323 Letters, 1st July to 31st December, 1903.
324 ,, 1st January to 30th June, 1904.
325 ,, 1st July to 31st December, 1904.
326 ,, 1st January to 30th June, 1905.
327 ,, 1st July to 31st December, 1905.
328 ,, 1st January to 30th June, 1906.
329 ,, 1st July, 1906, to 30th April, 1907.
330 ,, from Secretary, Inter-Colonial Council, No. 1.
331 ,, ,, ,, ,, 2.
332 ,, ,, ,, ,, 3
333 Crown Agents' Vouchers, No. 1.
334 ,, ,, ,, 2.
335 ,, ,, ,, 3.
336 Letters from Colonial Secretary's Office.
337 ,, H.M. Astronomer, Cape of Good Hope.

BOOKS.

338 Letter Register.
339 Index to Letter Register.
340 Stock Book—Details.
341 ,, Ledger.
342 Monthly Expenditure Book, No. 1.
343 ,, ,, ,, ,, 2.
344 ,, ,, ,, ,, 3.
345 Cash Book, No. 1.
346 ,, ,, 2.
347 Ledger.
348 Votes Ledger.
349 Vehicles, animals dead, sold, &c.
350 Staff and leave returns, &c.
351 Petty Expenditure.

LETTER BOOKS.

352 Letter Book, No. 1. 29th December, 1902, to 14th March, 1904.
353 ,, ,, 2. 14th March, 1904, to 23rd December, 1904.
354 ,, ,, 3. 23rd December, 1904, to 23rd October, 1905.
355 ,, ,, 4. 23rd October, 1905, to 5th January, 1907.
356 ,, ,, 5. 5th January, 1907, to April, 1907.

MANIFOLD LETTER BOOKS.

357–371 Manifold letter books, Nos. 1–15.
372 ,, ,, Topographic and Geodetic Survey.

TELEGRAM BOOK.

373–382 Telegram Books, Nos. 1–10.

ORDER BOOKS.

383–395 Order Books, Nos. 1–13.

Rail-Warrant Books.

396–400 Rail-warrant Books, Nos. 1–5 (for Tickets).
401–405 „ „ „ 1 to 5 (for Goods).

Cheque Books.

406–420 Cheque Books, Nos. 1–15.

Topographic and Geodetic Survey.

421 Portfolio with Correspondence.
422 „ *re* Stores.

Duplicate Receipts.

423 Duplicate Receipts, March, 1905, to April, 1907.

P. C. MORGENROOD.

REPORT OF MR. S. B. MORGENROOD ON THE COMPARATIVE COST OF SECTIONS AND SUB-SECTIONS OF SURVEY AND SOME ECONOMIES EFFECTED.

Introductory.

1. (*a*) In compiling this statement, the special object of the report has throughout been kept in view; namely, to supply data that are comparable and of service to others projecting work of the same kind on a similar scale.

(*b*) The figures were obtained by abstracting, recasting, and distributing the whole of the expenses recorded in the journals for the period covered by the survey, and the results, even if looked upon as approximate, will, in conjunction with the statements elsewhere of the equipment of the parties, provide useful data for the guidance of anyone interested.

(*c*) These data, too, serve another purpose; they prove, simply and directly, that the careful organisation and control exerted by the responsible officers have been effective in securing due economy in the carrying out of the survey.

(*d*) The tables supplied are:—

Table I. Detailed cost of sections.
„ II. „ „ sub-sections.
„ III. Average expenses per month in the field.

And, in order to render these tables of still better service, a few notes are added, separated for convenience under:—

Classification of Work.
„ Expenditure.
Distributions and Limitations.
Some Economies effected.

Classification of Work.

2. (*a*) The names given to the sections indicate the nature of the work performed, and as far as was practicable every expense incurred by or on behalf of any party has been included under its sub-section. The subdivision of observing, reconnaissance, and beaconing into sub-sections was done to make the compilation less general and more complete, and, as their equipment and the conditions under which they worked were not the same, useful information might accrue. As a matter of fact, Tables II and III. (Sub-sections), are the more useful for comparative purposes. For the same reason, the subsidiary work, though part of the primary triangulation, is, in the detailed part of the tables, kept separate.

(*b*) *Sections.* The headquarter section includes administrative, computing, and bar-comparison expenses. The latter is in reality an adjunct of the base-line work, but as the work was done by the headquarter staff, it, and the reductions of all the survey work, naturally come under headquarter expenses. Stationery for all parties is included under headquarters, as also books, maps, &c., which, however, form a separate heading. The remaining divisions of the work explain themselves.

(*c*) *Sub-sections* are arranged as nearly as possible in the order in which they took the field. Later parties, it will be noticed, made use of returned transport and other equipment, and in analysing the figures given this factor should be taken into account.

Classification of Expenditure.

3. (*a*) The heads under which the expenditure is divided are given in the first column, and the completeness of the classification is evidenced by the small amounts under sundries. Any further sub-division in the whole scheme would have made the tables too elaborate and laborious, although in the discussion of the results it may be necessary to partially sub-divide some.

(*b*) Most of these heads are again divided into, practically, *equipment purchases* and *expenses*, the latter being chiefly maintenance and repairs.

(*c*) *Railway* expenses, no matter in what connection, have been classed under a separate heading—Railage.

(*d*) *Instruments.*—The purchase column comprises actual instruments and instrumental appliances. The *special equipment* needed in connection with the same, such as bar huts, theodolite huts, specially constructed tripod stands and rings for the larger theodolites, &c., has been collected under a separate heading.

(*e*) So, too, a separate heading is given to special equipment *other than instrumental,* such as beacons, beacon fittings, bench marks, flagstaffs, special iron and wooden pickets, lead, cement, &c., which could hardly be classed as instrumental, and yet were not part of the ordinary camp equipment common to all parties.

(*f*) *Transport,* being a considerable item in the expenditure, has been broken up under various sub-heads. The maintenance columns include renewal purchases of worn-out halters, rugs, neck-bars, &c. Occasional, or hired, transport has been kept distinct from expenses with own transport.

(*g*) *Tents, tools, and camp equipment* are combined under one head, and in respect of tools and kitchen utensils the maintenance column includes renewal purchases of worn-out or broken articles.

(*h*) *Sundries* are mainly expendibles, such as wood, coal, candles, soap, &c., and a few small items which do not come under any other heading.

Distribution and limitations.

4. (*a*) For administrative purposes, and for other reasons connected with organisation and finance, the complete separation of accounts under the several sections of the work was not the most convenient, and, therefore, could not be strictly adhered to in the account books of the department, which have necessarily to be adapted to the forms in which, for each year, the funds are voted. Owing to officers in charge of sub-sections having been instructed to submit monthly statements of current expenditure direct to the head office, a considerable portion of the journal entries lent itself to subdivision and distribution, but, as can be expected, difficulties that seemed almost insurmountable occurred throughout the compilation, especially in connection with the mixed equipment purchases and the combined expenses in the initial and some later stages of the work. These were, however, with the aid of other records, overcome, and to enlarge upon them would be to needlessly take up space. It will suffice to mention to what extent the effects of these limitations upon the comparative value of the tables have been reduced.

(*b*) Whether in the classification of the headings or in the allocation of the expenditure, the introduction of purely arbitrary factors has been avoided as far as possible, in order to reduce cumulative errors as well as to prevent false proportions. Thus, the purchase columns do not necessarily include renewal purchases of broken or used-up parts of the equipment—these are more correctly part of the maintenance expenses, and have been included as such. Wherever possible, the actual sum expended has been debited to the actual party by or for whom it was incurred, and when not directly obtainable, it was arrived at as closely as possible. For instance, where a single account for fodder and grazing was rendered, and several parties had participated in the same, the number of animals of, and number of days shared by, each party was searched for in the records, and the proportionate charge worked out. Where full data were not obtainable, approximate proportions had to be adopted, these proportions being separately determined for each item of expenditure. It was felt that, in respect of purchases, errors of small amounts in the allocations to sub-sections could not seriously impair the usefulness of these tables, as they do not affect the averages of expenses nor the totals for each section. In the case of current expenditure, however, the more laborious course indicated above was imperative in order to arrive at just approximations.

One purely arbitrary division must be mentioned. During the months when the Superintendent was in the field on base reconnaissance and astronomical work, half his salary was debited (in these tables) to Headquarters and half to the field work.

(*c*) As shown elsewhere (*vide* Superintendent's Report, para. 132), the number of animals purchased was less than the number which would have been required had all parties taken the field simultaneously. Obviously, therefore, each party could not be debited with its actual strength in transport. To debit each party with a fixed proportion of the total cost of the animals, whilst perhaps justifiable in a general discussion of the work as a whole, would be an altogether arbitrary and fictitious allocation of pounds, shillings and pence, and of no instructive value for the objects of this section of the report. The only just, as well as instructive method, seems to be the one adopted of debiting and crediting each party with a certain number of animals purchased and sold, the numbers being more or less such as occurred in forming his party and including those that died, and to publish a separate statement tabulating the number of animals required for each party, debited to each, lost by death, and sold. This, too, is arbitrary, but less so, and has the advantage of providing data which will be of service to others organising similar work.

Similar arguments hold good, on a less scale, with regard to other transport articles, and in a still smaller degree, with regard to instruments. Thus it will be observed that far less than the actual cost of transport requirements has been charged to Observing Astronomical, Observing No. 2 Party, and Levelling; and practically no transport or tent equipment, except refitting charges, to Beaconing No. 4 and to subsidiary triangulation parties.

(*d*) The difference between the amounts of purchases thus tabulated and the cost of the full equipment required for each party, would represent the sum saved by organising a due succession of parties (*see* 5 *d*).

Results, and some economies effected.

5. (*a*) Most of the results are already referred to under each section of the main report, and supplementary data can be obtained from the tables. By way of emphasis, attention may be called in this section to the cases in which economy has been secured, and in this connection it must throughout be remembered that the survey was started and carried out at a most critical period in the history of the new Colonies, when living and every necessary was exceedingly expensive, a fact which makes some of the averages, especially those under transport, all the more remarkable.

(*b*) That the total outlay could easily have been much larger will be evident to anyone who has read the report. The principal general methods by which waste, both in time and expenses, has been kept under control are:—

I. Organisation and selection.
II. Limiting the personnel of parties to the minimum effective.
III. Limiting extraordinary expenses, such as railway travelling, &c.
IV. Decentralisation with central control, resulting in—
    1. Regulation and supervision with minimum friction;
    2. Responsibility and careful management on the part of sub-officers.

The above general methods are sufficiently self-evident not to need amplifying to any great extent. In the next two paragraphs, attention is directed to some of the ways in which organization has caused large savings. Minor ways in which outlay has been reduced will appear on taking the headings seriatim (para. (*e*) onwards).

(*c*) Many ways in which good organisation has resulted in large savings appear throughout the report. Thus, the Base Line party, with a large staff and heavy equipment, not only saved in transport, as detailed in para. 140, but considerably so in specialising the duties of each member of the staff as the work progressed, and more so in the time occupied in the measurements. All previous Base Measures are eclipsed in respect of the extent and the rapidity of the measurements. Again, comparing Reconnaissance, Beaconing, and Observing, it will be noticed that the ratio of the average number of points completed per month is nearly 2 : 1 : 1. That is to say, the Observing parties, with a larger apparent programme, took no longer to cover the ground than the Beaconing parties. This would have been impossible had not the work been properly subordinated, as explained in para. 25 (*j*) of the Superintendent's Report. The Beaconing parties had not merely to beacon points, but to remove all hindrances to the work, such as clearing bush, making platforms, and clearing up doubtful points in the reports as to routes, &c., even to the extent of reconnoitring new routes. It is evident that it is cheaper to allow the Beaconers to move steadily and delay a few days with a small trek of six animals, than to cause a corresponding delay to the Observing party with its larger personnel and 40 animals. (*See* Table III., last column.)

(*d*) Apart from the personnel, the gross cost of the field equipment was, in round numbers, £14,000. The saving effected in purchase of animals and equipment, merely, as a result of organising a succession of parties, amounts to, approximately, £3,500, of which £1,200 represents the saving in respect of No. 2 party alone. The field expenses total, similarly, to £13,000, half of which, or about £6,700, was for maintenance of over 150 animals during 2½ years. Details and averages for each section under each class of expenditure are provided in the tables.

(*e*) *Salaries.* Salaries naturally form more than half the total expenditure. The usual proportion in extensive work, not involving heavy machinery or construction expenses, is nearer three-quarters; and the reduced proportion on the Survey can be attributed to the fact that no section was overmanned, and that natives were trained wherever possible to do the minor work. In future surveys on a large scale, the utilization of trained natives could probably be still more advantageously adopted, especially in tropical countries. Each white assistant, and the majority of the natives, had definitely appointed work, and when the section on which they worked was completed, their services and pay usually ceased.

(*f*) *Allowances.* The small ratio of allowances to salaries prove how continuously men were kept in the field. The basis for allowances was domicile in the field, *i.e.*, to say, allowances were paid only when the men were, in connection with their duties, compelled to be away from their trek, as, for instance, when travelling by rail or on extended duty in a town. It was economic policy, therefore, to limit both these sources of waste, as the amounts prove. (*See* also Superintendent's Report, paras. 138-140.)

(*g*) *Natives.* In the earlier stages, native labour was very scarce and wages high, the rawest labourer having to be paid £3 per month and his food, whilst mule drivers received up to £5 per month. As the country got more settled, wages sank slightly and ranged from £2 to £4 per month. From the nature of the work, boys would not remain on unless food were provided, which cost from 12*s.* to 21*s.* per head per month, or, practically, 25 per cent. on their wages, but the satisfaction produced by this provision, reacting on the work, far outweighed the slightly increased cost.

(*h*) *Temporary Labour.* As the majority of the stations was in mountainous country, considerable delay would have ensued if only the fixed native staff were employed as bearers. Officers in charge were therefore instructed to engage temporary labourers on occupying a point, and again on leaving, and the Reconnaissance and Beaconing parties had to report on the supply available at each station. Very little difficulty was experienced in obtaining such, and a large saving in permanent wages, as well as in time, resulted. The cost per extra labourer per day ranged from 2*s.* to 5*s.*

(*j*) *Office Expenses.* The expenses for 3¾ years, comprising rent, rates, postal and telephone services, insurance, furniture, stationery, books, maps, &c., amount to about £1,500, of which about £200 are for books, maps, and stationery used by field parties. As with field parties, the staff was the absolute minimum, and the equipment such as is usually required with, in addition, various drawing and computing appliances. These latter are included under H.Q. Instrumental. Since the dwelling-house used as offices had no fire-extinguishing appliances, the instruments and fixtures were insured.

(*k*) *Instruments, &c.* The most noticeable feature is the high proportionate cost of the special equipment needed for the protection and proper use of the instruments in the field—a factor which should be taken into account when equipping. For observing work it averages about 30 per cent.; base measurement, 70 per cent.; and for the work as a whole, 40 per cent.

The gross expenditure incurred in connection with instruments was £2,824 10*s.* 2*d.*; and instrumental equipment, £1,138 13*s.* 5*d.* About £140 was spent in overhauling and refitting various instruments (some used on previous surveys), and but a very small sum in actual repairs—about £40 in all—chiefly on smaller instruments. Officers in charge were held personally liable, and as the risk of disorganising and delaying the whole work through accident to the larger instruments was too great to be entrusted to a native driver, observing officers took personal charge of these on trek and drove themselves.

(*l*) *Transport.* This from the nature of the work, is the head under which considerable expense is incurred, and in which most waste can take place unless there be effective organisation, supervision, and management. Instructions were issued as to the due care of animals and equipment, and while in the field, parties were again reminded against either over—or under—feeding. Accounts had to be sent in early each month, and any extraordinary expenditure was always open to query. That those in charge of parties used their common sense and bestowed due attention on the management of their trek can be seen on examining the table of average expenses. To eliminate differences in equipment, the range and average of expenses per unit per month are here given.

(*m*) *Vehicles.* The cost of maintenance for:—

Carts ranged from 5*s.* to 28*s.* per cart per month. Average, 18*s.* per month.
Wagons „ „ 28*s.* to 80*s.* „ wagon „ „ 54*s.* „ „
Harness „ „ 8*d.* to 20*s.* „ span of two per month. The longer in the field the higher are the maintenance expenses.

Average, with carts, 7*s.* per span per month, with wagons, 12*s.*

Thus it will be noticed, that apart from the reduced expense in respect of animals, carts are the more economical. Two carts are better than one wagon. They certainly require a little more care in loading and handling, but this is compensated by easier and more rapid travelling, and less risk from capsizes and breakages.

(*n*) *Animals*:—

(i.) The *cost of feeding* ranged from 14*s.* 6*d.* to 48*s.* per animal per month, or 6*d.* to 1*s.* 7*d.* per animal per day.

The average for more or less stationery parties and for rapidly moving parties, both of whom have less opportunities for good grazing, is 40*s.* per month, or 1*s.* 4*d.* per animal per day.

The average for steadily moving field parties is 25*s.* per month, or 10*d.* per animal per day.

The average for all parties is 31*s.* per month, or 1*s.* per animal per day.

(ii.) *Fodder* was varied as circumstances permitted. The prices were much higher in the earlier part of the work. Thus, oats averaged 15*s.* per 100 lbs., and later fell to about 10*s.* In some places, where fodder was unobtainable, seed oats at 22*s.* per 100 lbs. had to be used. Mealies averaged at first 12*s.* when obtainable, and later fell to 8*s.* and 6*s.* per 100 lbs. Oat-hay averaged 11*s.*, bran 13*s.*, and lucerne 10*s.*

(iii.) *Shoeing* ranged from 1*s.* to 5*s.* per animal per month. Parties used their discretion as to the need for shoeing, with considerable advantage. The total cost of shoeing is only two-fifths of what it would have been on the usual basis of 8*s.* for four shoes per animal per month; in other words, the saving in this respect is approximately £1,050.

	Staff.				Na			Maintenance Other Equipment.			Sundries.			Average Current Expenses per month (excl. Instr.).		
	Salaries.	Travelling Allowances.			Pay.											
BASE:	£	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Base Line	282	14	4	0	51	16	0	8	6	0	6	0	0	527	10	0
Base Reconnaissance ..	108	4	2	0	14	4	0	1	10	0	2	3	0	192	18	0
OBSERVING:																
Astronomical	115	5	16	0	21	3	0	1	11	0	3	2	0	228	0	0
No. 1 party	187	3	14	0	52	6	0	..			4	10	0	350	10	0
No. 2 „	221	2	5	0	59	8	0	..			3	19	0	360	11	0
Subsidiary (Obs. & Rec.)	75	0	8	0	15	8	0	..			1	6	0	127	14	0
RECONNAISSANCE:																
No. 1 party	66	4	11	0	11	15	0	..			1	8	0	133	2	0
No. 2 „	62	1	0	0	10	15	0	..			0	16	0	113	2	0
No. 3 „	75	3	3	0	13	5	0	..			2	13	0	149	15	0
BEACONING:																
No. 1 party	28	1	6	0	8	2	0	1	0	0	0	9	0	57	1	0
No. 2 „	29	0	15	0	11	13	0	1	5	0	0	17	0	69	13	0
No. 3 „	25	1	14	0	11	17	0	1	10	0	0	16	0	71	0	0
No. 4 „	25	0	8	0	13	7	0	0	12	0	0	16	0	81	9	0
Subsidiary	..	..			..			9	3	0	..			90	0	0
LEVELLING	110	2	2	0	23	18	0	..			2	12	0	187	8	0

(To face page 257.)

(iv.) *Veterinary* and other expenses. These ranged from 4*d.* to 5*s.* per animal per month. A little attention to the health of an animal goes a long way towards keeping it serviceable. This had been done by most parties at an average cost of 1*s.* 6*d.* per animal per month. In isolated cases, where this had been neglected, the feeding expenses have risen, with no corresponding advantage to the animal. Of 21 animals that suffered from horse sickness, 7 recovered, and 14 died. Among other expenses were small sums paid for watering animals in arid districts.

(*o*) *Railway and other Transport.* As stated, the use of these was limited to special circumstances in order to keep down expenses. One-third of the railway expenses and one-half of the other transport expenses were in connection with the Base line work, and of its total, over two-thirds was incurred in moving from Base to Base (*see* para. 140). Other parties used the railway only when requiring to move long distances to take up new chains, or on completing work. Observing party No. 1 (Capt. Gordon's) kept expenses down by trekking on starting work, resuming at Nthubankulu, and on completion. This could not always be done, owing to risks from horse sickness, &c.

(*p*) Doubtless there are many other minor ways in which saving has been, and could be, effected. Sufficient has been said to show that the matter of economy was given due consideration by those responsible, and to show others organising similar work in what directions such is most easily attained.

S. B. MORGENROOD

REPORT OF Mr. S. B. MORGENROOD ON THE CLASSIFICATION AND RECORDS OF REPORTS ON TRIGONOMETRICAL STATIONS AND ROADS CONNECTING THEM.

General remarks.

1. Copies of the reports and sketches of reconnaissance and beaconing officers have been arranged in sets, each set placed in a separate envelope together with an index, and the envelope docketed. Duplicate sets have also been arranged and indexed similarly, so that if in any future work the reports on the trigonometrical stations are required, copies could be made from the duplicate sets as far as possible. Original manuscripts and copies, where available, are filed in the report-files of each officer.

Lists of Records.

2. Lists of the records are here given. In these lists are tabulated :—

A. Adopted trigonometrical stations, arranged in the same groups as in the Descriptive List, and in the same order. The data given are—

(1.) Name of station.

(2.) Reference number in the computations.

(3.) Nature of record, whether report only, or report with outlines and sketches.

(4.) By whom reported on.

In this list, and in the Descriptive List, it may be noted that where the computation reference numbers are consecutive, the stations in group and circuit chain coincide ; where there is a break in the order of reference numbers, the station is in a different circuit ; *e.g.*, in Group I., Nos. 1–5, with odd reference numbers, belong to Circuit chain No. 8 ; the rest of the group belong to Circuit chain No. 11.

B. Other points visited by reconnaissance and beaconing parties, and the nature of the records, which are in the files of the officers named.

C. Road reports and schemes of movements in connection with each chain of triangles, numbered consecutively (the number being that by which the report is referred to in the scheme of movements), with approximate distance in miles, and by whom reported on.

A.

LIST OF TRIGONOMETRICAL STATIONS OF WHICH THERE ARE RECORDS AT THE HEAD OFFICE.

The following abbreviations are used :—

R=Record of a written report.
O=Outlines of distant country.
E=Eye-sketch of point and surroundings (to varying scales).
S=Sketch to scale of ground immediately about station.

	Name of Station.	Reference Number.	Record.	By whom reported on.
	GROUP I.—KIMBERLEY TO OTTOSHOOP.			
1.	Aasvogel Kop	162	R O E	T. N. Dunman.
2.	Tarantal Kop	152	R O E	T. N. Dunman.
3.	Boshof Hill	165	R O E	T. N. Dunman.
4.	Spion Kop	166	R E S	C. H. Ley.
5.	Kameelpan II.	167	R O E	Ley.
6.	Zwart Kop II.	183	R O S	Ley.
7.	Boesmans Kop	184	R O S	Ley.
8.	Uitkyk	185	R O S	Ley.
9.	Leeuwlaagte	186	R O E	Ley.
10.	Winterhoek	187	R E	Ley.
11.	Boomplaats	188	R S	Ley.
12.	Houtnek	189	R E	Ley
13.	Beth-el-Pella	190	R E	Ley.
14.	Schoonheid	191	R E	Ley.
15.	Langvallei	192	R E	Ley.
16.	Never Mind	193	R E	Ley.
17.	Kopje Enkel	194	R	Ley.
18.	Kameelpan I.	195	R E	Ley.
19.	Smitskraal	196	R E	Ley.
20.	Nooitgedacht	197	R E	Ley.
21.	Amsterdam	198	R	Ley.
22.	Klipkuil	199	R	Ley.
23.	Doornhoek	200	R E	Ley.
24.	Holpan	201	R E	Ley.
25.	Morgenzon	202	R E	Ley.
26.	Panfontein	203	R E	Ley.
27.	Makous Kop	204	R E	Ley.
28.	Strap Pan	205	R E	Ley.
29.	Doornbult III.	206	R E	Ley.
30.	Rosalie	207	R E	Ley.
31.	Rietpan	208	R	Ley.
32.	Dornbult II.	209	R E	Ley.
33.	Simon's Vlei	210	R	Ley.
34.	Zwart's Rust	211	R	Ley.
35.	Boschpan	212	R E	Ley.
36.	Karee Kuil	213	R E	Ley.
37.	Disselboom Pan	214	R E	Ley.
38.	Driekuil	215	R E	Ley.
39.	Middel Bult	216	R E	Ley.
40.	Makoiespan	217	R E	Ley.
41.	Doornbult I.	218	R	Ley.
42.	Bethlehem	219	R E	Ley.
43.	De Paarl	220	R E	Ley.
44.	Houthaal Boomen	221	R E	Ley.
45.	Sypher Pan	222	R E	Ley.
46.	Welverdiend	223	R E	Ley.
47.	Molopo's Oog	224	R E	Ley.
48.	Polfontein	225	R E	Ley.
49.	Grootfontein	226	R	Ley.
50.	Klip Pan	227	R E	Ley.

RECORD OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP II.—WOLMARANSTAD TO KROONSTAD.

Name of Station.	Reference Number.	Record.	By whom reported on.
1. Leeuwfontein	228	R E	Ley.
2. Schietfontein	229	R E	Ley.
3. Rhenosterberg Hoek	230	R E	Ley.
4. Doornplaat	231	R E	Ley.
5. Klerksdorp	232	R E	Ley.
6. Vlaklaagte	233	R E	Ley & Dunman.
7. Paradys	234	R E	Ley & Dunman.
8. Bovenland Plaats	235	R O E	Ley & Dunman.

GROUP III.—NEWCASTLE TO BELFAST.

Name of Station.	Reference Number.	Record.	By whom reported on.
1. Salt Lake	57	R O E	Ley & Gill.
2. Inkwelo	59	R O E S	K., M. & Gor.
3. Ntabankulu	60	R O E S	Dun. & Gor.
4. Langberg I	61	R O S	K. & Gor.
5. Hlamimpisiberg	62	R O E S	D., M. & Gor.
6. Elandsberg III	63	R O E S	K., M. & Gor.
7. Blauw Kop	64	R E S	K., M. & Gor.
8. Spitzkop I	65	R O E S	K., M. & Gor.
9. Tafelkop (Ermelo)	66	R O E S	K., D. M. & Gor.
10. Sterkfontein	67	R O E S	D., M. & Gor.
11. Vlakfontein	68	R O E S	K., M. & Gor.
12. Baatjes Bult	69	R O E S	Dun. & Gor.
13. Tafelkop (Devil's Kantoor)	70	R O E S	K., M. & Gor.
14. Verloren Vlei	71	R O E S	King & Gor.
15. Wonderfontein	72	R O E	King & Morg.
16. Panplaats	73	R O E S	D., M. & Gor.
17. Belfast	74	R O E	Morgenrood.
18. Langkloof	75	Nil.	
19. Mare's Kop	76	Nil.	
20. S. end, Belfast Base	77	R	Simms.
21. N. end, Belfast Base	78	R	Simms.
22. Groot Riet Vlei	79	R O E S	K., M. & Gor.
23. Paarde Kop I	80	R O E S	K., M. & Gor.

GROUP IV —BELFAST TO LIMPOPO.

Name of Station.	Reference Number.	Record.	By whom reported on.
1. Mount Anderson	236	R O	King & Gill.
2. Thama Koosh	237	R O	King & Gill.
3. Manoutsa	238	R O	King & Gill.
4. Iron Crown	239	R O	King & Gill.
5. Portugal	240	R O	King & Gill.
6. Schnell's Kop	241	R O	King & Gill.
7. Matala	242	R O E	King & Gill.
8. Loskop	243	R O	King & Gill.
9. Kameel Kop	244	Nil.	
10. S. end, Houts R. Base	245	R	Simms.
11. N. end, Houts R. Base	246	R	Simms.
12. Blaauwberg	247	R O E	King & Gill.
13. Lejuma	248	R O	King & Gill.
14. Dwarsberg	249	R O	King & Gill.
15. Pont	250	R O	King & Gill.
16. Dogola	251	R O E	King & Gill.

GROUP V.—BELFAST TO OTTOSHOOP.

Name of Station.	Reference Number.	Record.	By whom reported on.
1. Rhenoster Kop	81	R E S	D., M. & Gor.
2. Quaggafontein	82	R E S	D., M. & Gor.
3. Zwartkloof	83	R O E	D., M. & K.
4. Cable Hill	84	R E S	D., M. & Gor.

RECORD OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP V.—BELFAST TO OTTOSHOOP—*continued.*

Name of Station.	Reference Number.	Record.	By whom reported on.
5. Boshofsberg	85	R O E S	D., M. & Gor.
6. Nooitgedacht I	86	R O E	D. & M.
7. Pilaudsberg	87	R O E S	D., M. & Gor.
8. Tafelkop	88	R E S	D., M. & Gor.
9. Kaalkop	89	R E S	D., M. & Gor.
10. Onverwacht	90	R E S	D., M. & Gor.
11. Enzelberg	91	R O E S	D., M. & Gor.
12. Witzkop I.	92	R S	D., M. & Gor.
13. Vergenoeg	93	R S	D., M. & Gor.
14. N. end, Ottoshoop Base	94	R	Simms.
15. S. end, Ottoshoop Base	95	R	Simms.

GROUP VI.—PRETORIA TO CAPE COLONY.

Name of Station.	Reference Number.	Record.	By whom reported on.
1. Johannesburg	96	R O	King.
2. Blyvooruitzicht	97	R O	King.
3. Paardekop II.	98	R O E	King.
4. Witkop II.	99	R O	King.
5. Elandskop I.	100	R O	King.
6. Vliegenkraal	101	R O	King.
7. Spitzkop II.	102	R O	King.
8. Liebenbergstroom	103	R O E	King.
9. Doornkop	104	R	King.
10. Rhenosterkop II.	105	R O	King.
11. Boschrand	106	R O	King.
12. Braamzynkop	107	R O	King.
13. W. end, Kroonstad Base	108	R	Simms.
14. E. end, Kroonstad Base	109	R	Simms.
15. Rietfontein	110	R O	King.
16. Elandskop II.	111	R O	King.
17. Kaffir Kop	112	R O	King.
18. Mynhardt's Rust	113	R O	King.
19. Zwartkraus	114	R O E	King.
20. Rhebokberg	115	R O	King.
21. Machache	116	R O E	King.
22. Mabula	117	R O	King.
23. Thaba Putsua	118	R O	King.
24. Thaba Tsueu	119	R O	King.
25. Jammersberg	120	R O E	Dunman.
26. Dikhoele	121	R O	King.
27. N. end, Wepener Base	122	R	Simms.
28. S. end, Wepener Base	123	R	Simms.
29. Gobo-Gobo	124	R O	Dunman.
30. Aasvogelberg	127	R O E	King & Morg.
31. Nthodimonate	128	R O E	King.
32. Helvelyn	129	R O E	King & Morg.
33. Bendearg	130	R O E	King & Morg.
34. Waschbank Peak	131	R O E	King & Morg.
35. Xuka	10	R O E	King & Morg.
36. Lubisi	8	R O E	King & Morg.
37. Oweoweni	9	R E	Morgenrood.

GROUP VII.—KIMBERLEY TO NEWCASTLE.

Name of Station.	Reference Number.	Record.	By whom reported on.
1. Scholtz Kop	149	R O E	Dun. & Gill.
2. Paardeberg	163	R O E	Dun. & Gill.
3. Rondefontein	164	R O E	Dun. & Gill.
4. Kareelaagte	168	R O E	Dun. & Gill.
5. Du Plessis Dam	169	R O E	Dun. & Gill.
6. Bosberg	170	R O E	Ley & Gill.
7 Weltevreden	171	R O E	Dun., Ley & Gill.
8. Biesie Pan	172	R O E	Ley & Gill.
9. Schoongezicht	173	R O E	Dun., Ley & Gill,
10. Theron's Kop	174	R O E	Ley & Gill,

RECORD OF TRIGONOMETRICAL STATIONS—*continued.*

Name of Station.	Reference Number.	Record.	By whom reported on.
GROUP VII.—KIMBERLEY TO NEWCASTLE—*continued.*			
11. Zoetvlei	175	R O E	Ley & Gill.
12. Nooitverwacht	176	R O E	Dun. & Gill.
13. Langberg II.	177	R O E	Ley & Gill.
14. Vierfontein	178	R O E	Ley & Gill.
15. Vaalbank Kop	179	R O E	Ley & Gill.
16. Kaal Kop	180	R O E	Ley & Gill.
17. Hermitage	181	R O E	Ley & Gill.
18. Gemsbok Berg	182	R O E	Ley & Gill.
19. Drakensberg	58	R O E	Ley & Gill.
GROUP VIII.—HOPE TOWN TO WEPENER.			
1. Bester's Kop	133	R O E	Dunman & Ley.
2. Orange River	134	R O E	Dunman & Ley.
3. Wonderkloof	135	R O E	Dunman & Ley.
4. Boschjes Pan	136	R O	Ley.
5. Platkop	137	R O E	Dunman & Ley.
6. Fauresmith Hill	138	R O E	Dunman & Ley.
7. Lokshoek	139	R O E	Dunman & Ley.
8. Luipers Rand	140	R O E	Dunman & Ley.
9. Drie Baden	141	R O E	Dunman & Ley.
10. De Put	142	R O E	Dunman & Ley.
11. Lemoenfontein	125	R O E	Dunman & Ley.
12. Koesberg	126	R O E	Ley.

Of the following Secondary Stations, between Cable Hill, Pretoria and Johannesburg, there are no descriptive reports, nor sketches :—

Name of Station.	Reference Number.	—
Daspoort	252	
Muckleneuk	253	NOTE.—The diagram of these secondary Stations is given on Diagram I. of the Survey.
Meintjes Kop	254	
Koedoes Poort	255	
Camp	256	
Klapper Kop	257	
Zwart Kop III.	258	
Irene	259	
Brakfontein	260	
Olifantsfontein	261	
Klipfontein	262	
Witpoort	263	
Driefontein	264	
Germiston	265	
P. 6	266	A point of Rand Survey.
Klip River Berg	267	A point of Rand Survey.

B.

ADDENDA TO LIST OF TRIGONOMETRICAL STATIONS.

The following is a list of other points visited by the Reconnaissance parties, but not used as Trigonometrical Stations in the ultimate scheme. Some of these points were beaconed and fully reported upon; others were only partially reported upon; most of them, having been rejected in the course of the reconnaissance, were not reported upon at all.

(C = Correspondence file.)

Name of Station.	Record.	By whom reported on.
Shepstone Lake, Natal (beaconed)	R C E	K., D. & M.
Majuba, Natal (beaconed)	C	King.
Hlamimvubu, E. of Hlamimpisi	C	Dunman.
Maryvale, Spring-grove, and Bussy, Swaziland	..	King.
Klipfontein, Carolina	R	Dunman.
Little Spitzkop, Godwaan	C	Dunman.
Spitzkop, Lydenburg	C	King.
Mauchberg, Lydenburg	C	King.
Zuikerbosch Kop, Lydenburg	C	King.
Wanhoop, Steenekamps Berg	C	King.
Buiskop, Nylstroom	C	Dunman.
Rooiberg, Nylstroom	C	Dunman.
Strydpoort, Chunie Mountains	R	King.
Boschpoort, Magnet Heights	R	King.
Krematatberg, Buffelskop	R E	King.
Wegdraai, Zoutpansberg	R	King.
Groothoek, Waterberg	R C	King.
Doornkom, Waterberg	R C	King.
Donker Kloof, Waterberg	R C E	King.
Hanglip, Waterberg	R C E	King.
Schoongelegen, Waterberg	R C E	King
Koedoes Rand, Waterberg	R C	King.
Vliegepoort Kop, Rustenburg	R	King
Geelhout Kop, Rustenburg	C	King.
Kleinfontein, Potchefstroom	R C E	Dunman.
Paarde Kop, Potchefstroom (beaconed)	R E	Dunman.
Platberg, Klerksdorp (beaconed)	R E	Dunman.
Rhenoster Spruit, Klerksdorp (beaconed)	R E	Dunman.
Leeuwkop, Makwassiberg (beaconed)	R E	Dunman.
Kareepan, Wolmaranstad	R E	Dunman.
Doornfontein, Ventersdorp	R E	Dunman.
Bulfontein, Lichtenburg	R E	Dunman.
Brakpan, Lichtenburg	R E	Dunman.
Syferpan, Lichtenburg	R E	Dunman.
Doornbult, Lichtenburg	R E	Dunman.
Machavie Hills, Klerksdorp	C	Dunman.
Aasvogel Rand, Vredefort, O.R.C.	C	Dunman.
Rappardsvlakte, Bothaville, O.R.C.	R E	Dunman.
Leeuwkop, Boshof, O.R.C.	R E	Dunman.
Bushman's Kop, Rouxville, O.R.C.	C	Dunman.
Tafelkop, Vrede, O.R.C.	R E	Ley.
Vaalkop, Vrede, O.R.C.	R E	Ley.
Aasvogelkop, Ventersburg, O.R.C.	C	King.
Olyvenhoutfontein, Heilbron, O.R.C.	C	King.
Spitzkop, Senekal, O.R.C.	C	King.
Tandjesberg, Basutoland	C	King.
Thaba Bosigo, Basutoland	C	King.
Papanyane Mountains, Basutoland	C	King.
Udu-Udu Mountains, Basutoland	C	King.
Lerothodi Mountains, Basutoland	C	King.
Snowdon, Herschel, C.C.	C	King.
Bottel Nek, Barkly E., C.C.	C	King.

C.

ROAD REPORTS

Groups III. to VIII.

NOTE.—For Groups I. and II. no Road Reports were recorded, as the Observing Officer did his own Reconnaissance.

GROUP III.—NEWCASTLE TO BELFAST.

	Roads.	Miles.	By whom reported on.
1.	Newcastle to Salt Lake	15	King.
1 & 2.	Inkwelo, *viâ* Newcastle, to Salt Lake	36	S.B.M.
3.	Newcastle, *viâ* Utrecht, to Wakkerstroom	35	King.
3A.	Inkwelo, *viâ* Volksrust, to Wakkerstroom	25	S.B.M.
4.	Wakkerstroom to Langberg	16	S.B.M.
5.	Wakkerstroom to Ntabankulu	24	S.B.M.
6.	Ntabankulu to Langberg	39	King.
7.	Wakkerstroom to Hlamimpisiberg (condensed)	30	T.N.D.
8.	Inkwelo to Langberg (direct) .. Notes	..	King.
8A.	Ntabankulu to Hlamimpisi, *viâ* Luneberg	52	T.N.D.
9.	Wakkerstroom to Hlamimpisiberg	30	T.N.D.
9A.	Wakkerstroom to Hlamimpisiberg .. Addenda	..	S.B.M.
10.	Langberg to Elandsberg	16	King.
10A.	Langberg to Elandsberg .. Addenda	..	S.B.M.
11.	Spitzkop to Hlamimpisiberg .. Notes	47	King.
12.	Elandsberg to Blaauwkop	35	King.
13.	Blaauwkop to Tafelkop (Ermelo)	30	King.
13A.	Blaauwkop to Tafelkop .. Addenda & Sketch	..	S.B.M.
14.	Elandsberg to Hlamimpisiberg	31	King.
15.	Tafelkop (Ermelo) to Spitzkop (Alkmaar)	27	King.
15A.	Tafelkop(Ermelo) to Spitzkop(Alkmaar) Addenda & Sketch	..	S.B.M.
16.	Tafelkop to Sterkfontein	13	S.B.M.
16A.	Sterkfontein to Baatjesbult	28	S.B.M.
16B.	Tafelkop to Sterkfontein to Baatjesbult	40	T.N.D.
17.	Baatjesbult to Vlakfontein	24	King.
17A.	Baatjesbult to Vlakfontein .. Addenda	..	S.B.M.
17B.	Tafelkop to Vlakfontein	37	King & D.
18.	Elandsberg to Ermelo .. Notes	..	King.
18A.	Elandsberg to Ermelo .. Addenda	49	S.B.M.
19.	Carolina to Wonderfontein	25	King & D.
	Carolina to Wonderfontein .. Addenda	..	S.B.M.
19A.	Carolina to Belfast	29	T.N.D.
	Carolina to Belfast .. Addenda	..	S.B.M.
19B.	Sterkfontein to Wonderfontein	55	D. & K.
20.	Baatjesbult to Tafelkop (Devil's Kantoor)	74	King.
20A.	Tafelkop to Godwaan, *viâ* Barberton	48	King.
	Remarks on 20 and 20A	..	M. & D.
20B.	Godwaan R. to Tafelkop, *viâ* Kaapsche Hoop	24	S.B.M.
21.	Belfast to Verloren Vlei	28	King & D.
21A.	Belfast to Verloren Vlei .. Addenda	..	S.B.M.
22.	Belfast to Wonderfontein .. „	12	D. & M.
22A.	Belfast to Mare's Kop	15	T.N.D.
22B.	Belfast to Langkloof	9½	S.B.M.
22C.	G. R. Vlei and Panplaats to Langkloof	18 & 13	S.B.M.
23.	Verloren Vlei to Groot Riet Vlei	30	T.N.D.
24.	Groot Riet Vlei to Paardekop	38	T.N.D.
24A.	Groot Riet Vlei to Paardekop .. Addenda	..	S.B.M.
24B.	Paardekop to Pogwane .. Additional Notes	13	S.B.M.
25.	Wonderfontein to Panplaats .. Addenda	14	D. & M.
26.	Panplaats to Groot Riet Vlei .. „	15	D. & M.

ROAD REPORTS—*continued.*

Roads.	Miles.	By whom reported on.
GROUP IV.—BELFAST TO LIMPOPO.		
0. Thama Koosh to Paardekop II	39	King.
1. Verloren Vlei to Mount Anderson	54	King.
1A. Lydenburg to Mount Anderson	18	Gill.
2. Mount Anderson to Thama Koosh	67	King.
3. Mount Anderson to Manoutsa	49	Gill.
4. Manoutsa to Thama Koosh	62	Gill.
5. Thama Koosh to Portugal	87	King.
5A. Thama Koosh to Portugal *viâ* Chunie's Poort	75	Gill.
6. Portugal to Iron Crown	56	Gill.
6B. Eersteling to Pietersburg	16	King.
7. Iron Crown to Manoutsa	80	King.
8. Haenertsburg to Schnellskop	12	King.
8A. Iron Crown to Schnellskop	16	Gill.
9. Iron Crown to Pietersburg	40	King.
9A. Iron Crown to Pietersburg	40	Gill.
10. Woodbush to Pietersburg	30	King.
10A. Schnellskop to Pietersburg	30	Gill.
11. Pietersburg to Matalas	31	King.
11A. Pietersburg to Matalas	31	Gill.
12. Pietersburg to Loskop	29	Gill.
13. Pietersburg to Mara	59	King.
14. Matala to Loskop	29	King.
15. Loskop to Lejuma	30	Gill.
16. Loskop to Blaauwberg	42	King.
17. Mara to Beauley	39	King.
17A. Lejuma to Blaauwberg	38	Gill.
18. Beauley to Dwarsberg	50	King.
18A. Blaauwberg to Dwarsberg	55	Gill.
19A. Dwarsberg to Pont	61	Gill.
19B. Dwarsberg to Krematatberg	22	King.
19C. Krematat to Wegdraai	25	King.
19D. Wegdraai to Pont	17	King.
20. Pont to Dogola	56	King.
20A. Pont to Dogola	56	Gill.
21A. Dogola to Pietersburg	91+43=131	Gill.
21B. Wegdraai to Witfontein	56	King.
GROUP V.—BELFAST TO OTTOSHOOP.		
27. Paardekop to Oliphant's River	28	T. N. D.
27A. Paardekop to Quaggafontein	57	S. B. M.
28. Stoffberg to Quaggafontein	70	T. N. D.
29. Massoeps Drift to Middelburg	108	T. N. D.
29H. G. R. Vlei and Panplaats to Middelburg	24	S. B. M.
30. Middelburg to Rhenoster Kop	42	T. N. D.
30A. Middelburg to Rhenoster Kop .. .. Addenda	..	S. B. M.
31. Quaggafontein to Rhenoster Kop, via Witkop	62	T. N. D.
32. Rhenoster Kop to Cable Hill	54	T. N. D.
32A. Rhenoster Kop to Cable Hill	55	S. B. M.
33. Cable Hill to Warmbaths	60	T. N. D.
34. Quaggafontein to Warmbaths	77	T. N. D.
34A. Quaggafontein to Warmbaths .. .. Addenda	..	S. B. M.
35. Warmbaths to Zwartkloof and Boshofsberg	40	T. N. D.
35A. Warmbaths to Zwartkloof and Boshofsberg	..	S. B. M.
36. Boshofsberg to Rustenburg	78	T. N. D.
37. Rustenburg to Nooitgedacht	38	T. N. D.
37H. Cable Hill to Nooitgedacht, ... Addenda	46	D. & M.
38. Rustenburg to Pilandsberg	46	T. N. D.
38A. Rustenburg to Pilandsberg and Saulspoort to Koedoesfn	..	S. B. M.
38H. Boshofsberg to Pilandsberg (with sketch)	80	S. B. M.
39. Pilandsberg to Kaalkop	51	T. N. D.
39H. Tafelkop to Kaalkop	35	T. N. D.
40. Kaalkop to Enzelberg	52	T. N. D.
41. Enzolberg to Vergenoeg	18	T. N. D.
42. Vergenoeg to Witkop	16	T. N. D.
43. Witkop to Paardeplaats	..	T. N. D.
43H. Zeerust to Paardeplaats	12	T. N. D.
44. Paardeplaats to Tafelkop	40	T. N. D.
45. Rustenburg to Tafelkop	45	T. N. D.
Addenda to Roads 39 to 45, *see* Addenda to Trigonometrical Points	..	S. B. M.
Scheme of Movements, Belfast to Ottoshoop.		

ROAD REPORTS—*continued.*

Roads.	Miles.	By whom reported on.
GROUP VI.—PRETORIA, VIA KROONSTAD AND WEPENER, TO CAPE COLONY.		
1. Pretoria to Nooitgedacht	46	King.
2. Pretoria to Observatory Hill (Johannesburg)	45	Middleton.
3. Nooitgedacht to Kleinfontein	58	King.
3A. Kleinfontein to Blyvooruitzicht	11	King.
4. Blyvooruitzicht to Losberg	22	King.
4A. Losberg to Witkop	16	Mid.
5. Losberg to Vereeniging	20	King.
5A. Vereeniging to Meyerton	9	King.
5B. Meyerton to Paardekop	12	King.
6. Blyvooruitzicht to Paardekop	50	Mid.
7. Vereeniging to Witkop	30	King.
8. Witkop to Vliegenkraal	29	King.
9. Vliegenkraal to Rhenosterkop	24	King.
9A. Vliegenkraal to Rhenosterkop (road sketch)	..	Mid.
10. Rhenosterkop to Kroonstad	11	King.
11. Kroonstad Drift to Boschrand	5	Mid.
12. Kroonstad to Doornkop	10	King.
13. Doornkop to Leibenbergstrom	25	King.
14. Liebenbergstroom to Spitzkop	15	Mid.
15. Elandskop I. to Spitzkop	17	King.
16. Leibenbergstroom to Elandskop II.	23	King.
17. Elandskop II. to Lindley	19	King.
18. Lindley to Rietfontein	16	King.
19. Kroonstad to Rietfontein	26	King.
20. Lindley to Kaffirkop	18	King.
20A. Lindley to Kaffirkop (road sketch)	..	Mid.
21. Kaffirkop to Mynhardtsrust	36	King.
22. Mynhardtsrust to Rheobokberg	53	King.
22A. Mynhardtsrust to Senekal (sketch)	..	Mid.
23. Senekal to Rietvlei (Zwaartkrans) (sketch)	25	Mid.
24. Rheebokberg to Rietvlei (Zwaartkrans)	44	King.
24A. Rheebokberg to Ficksburg	27	Mid.
24B. Zwaartkrans to Ficksburg	26	King.
24C. Zwaartkrans to Ficksburg (road sketch)	..	Mid.
25. Ficksburg to Ladybrand	33	King.
25A. Ficksburg to Ladybrand (road sketch)	..	Mid.
26. Ladybrand to Maseru	11	King.
27. Ladybrand to Mabula (sketch)	15	K. & M.
28. Ficksburg to Thabanchu (sketch)	64	K. & M.
29. Thabanchu to Wepener (sketch)	41	Mid.
30. Maseru to Theko's store (sketch)	19	K. & M.
31. Trail: Theko's to Machache	12 (4½ hrs.)	K. & M.
32. Theko's store to Koro Koro store	11 ,,	K. & M.
33. Track: Koro Koro's to Putsua Mount	25 (12 hrs.)	K. & M.
34. Koro Koro's to Thaba Tsueu	29	K. & M.
35. Thaba Tsueu to Dikhoele (Mafeteng)	10	Mid.
36. Mafeteng to Wepener	13	King.
37. Wepener to Gobo Gobo	16	King.
38. Gobo Gobo to Zastron	..	King.
39. Zastron to Mohaleshoek	..	King.
40. Mohaleshoek to Moyeni (Nthodimonate)	35	K. & M.
41. Tsuaing R. to Thaba Tsueu	7	King.
42. Moyeni to Lady Grey	47	King.
43. Notes on Roads N.E. of Cape Colony	..	Morg.
44. Zastron to Lady Grey (Helvellyn)	42–75	Morg.
45. Helvellyn to Bendearg	88	Morg.
45A. Lady Grey to Barkly East, thence to Barkly Pass and Glenorchy	..	King.
46. Helvellyn to Waschbank Peak	91	Morg.
46A. Bendearg to Waschbank Peak	87	Morg.
47. Bendearg to Xuka, *viâ* Elliott	37	Morg.
47A. Barkly Pass to Elliott	11	King.
48. Xuka to Lubisi	60	Morg.
48A. Elliott, via Cala to Southeyville	45	King.
49. Waschbank to Xuba, *viâ* Indwe	80	Morg.
49A. Waschbank to Lubisi, *viâ* Indwe	60	Morg.
50. Lubisi to Cwecweni, *viâ* Ncolora	39	Morg.
51. Indwe to Elliott	33	Morg.
52. Askeaton to Indwe	16	King.

ROAD REPORTS—*continued.*

GROUP VII.—KIMBERLEY TO NEWCASTLE.

	Roads.	Miles.	By whom reported on.
0.	Inkwelo to Newcastle	20	*See* III. (1).
1.	Newcastle to Mount Prospect (road sketch)	..	Ley.
2.	Newcastle to Drakensberg (road sketch)	..	Ley.
3.	Drakensberg to Gemsbokberg	34	Ley.
3A.	Drakensberg to Gemsbokberg	34	Gill.
4.	Gemsbokberg to Hermitage (road sketch)	..	Ley.
4A.	Gemsbokberg to Hermitage (road sketch)	22	Gill.
5.	Hermitage to Newmarket (road sketch)	26	Ley.
5A.	Newmarket to Kaalkop (road sketch)	14	Ley.
5B.	Hermitage to Kaalkop	20	Gill.
6.	Kaalkop, *viâ* Newmarket to Vaalkop (sketch)	36	Ley.
6A.	Kaalkop to Vaalbankkop	23	Gill.
7.	Vaalbank-kop to Vierfontein (sketch)	..	Ley.
8.	Vierfontein to Langberg II.	32	Gill.
9.	Vaalbank-kop to Langberg (road sketch)	42	Ley.
10.	Kroonstad to Braunzijnkop	26	Gill.
11.	Braunzijnkop to Boschrand W.	18	Gill.
11A.	Braunzijnkop to Nooitverwacht	40	Ley.
12.	Boschrand to Nooitverwacht	20	Gill.
12A.	Bothaville to Nooitverwacht	8	Dunman.
13.	Nooitverwacht to Rappardsvlakte	26	Gill.
14.	Rappardsvlakte to Zoetvlei	20	Dunman.
14A.	Rappardsvlakte to Zoetvlei	20	Gill.
14B.	Posenbluff to Zoetvlei .. Notes	..	Dunman.
15.	Zoetvlei to Theron's Kop	36	Gill.
15A.	Posenbluff to Theron's Kop .. Notes	..	Dunman.
16.	Zoetvlei to Biesiepan .. Notes	..	Dunman.
16A.	Zoetvlei to Schoongezicht .. Notes	..	Dunman.
16B.	Smaldeel to Schoongezicht	20	Gill.
17.	Schoongezicht to Bosberg .. Notes	..	Dunman.
17A.	Schoongezicht to Biesiepan	22	Gill.
18.	Bosberg to Kareelaagte	41	Dunman.
19.	Kareelaagte to Du Plessis Dam .. Notes	..	Dunman.
19A.	Kareelaagte to Du Plessis Dam	20	Gill.
20.	Biesiepan to Weltevreden .. Notes	..	Dunman.
20A.	Biesiepan to Bosberg	13	Gill.
21.	Bosberg to Weltevreden	31	Dunman.
21A.	Bosberg to Weltevreden	26	Gill.
22.	Weltevreden to Du Plessis Dam .. Notes	..	Dunman.
22A.	Weltevreden to Du Plessis Dam	20	Gill.
23.	Boshof to Du Plessis Dam	24	Dunman.
24.	Kareelaagte to Boshof Hill	24	Dunman.
24A.	Kareelaagte to Boshof Hill	24	Gill.
25.	Rondefontein to Kareelaagte	22	Dunman.
26.	Paardeberg to Rondefontein	28	Dunman.
26A.	Paardeberg to Rondefontein	28	Gill.
27.	Boshof Hill to Paardeberg .. Notes	..	Dunman.
28.	Boshof Hill to Rondefontein .. Notes	.	Dunman.
28A.	Boshof Hill to Rondefontein	21	Gill.
29.	Boshof Hill to Tarantaalkop	15	Dunman.
30.	Boshof Hill to Aasvogel Kop	13	Dunman.
30A.	Boshof Hill to Aasvogel Kop	13	Gill.
31.	Aasvogelkop to Scholtzkop	27	Dunman.
32.	Aasvogelkop to Tarantaalkop .. Notes	..	Dunman.
32A.	Aasvogelkop to Tarantaalkop	15	Gill.
33.	Tarantaalkop to Scholtzkop	22	Dunman.
34.	Paardeberg to Scholtzkop	11	Gill.
35.	Kimberley to Tarantaalkop	12	Gill.

GROUP VIII.—HOPETOWN TO WEPENER.

1.	Orange R. Station to Elandsdraai	5	Dunman.
2.	Elandsdraai to Besterskop	28	Ley.
3.	Besterskop to Wonderkloof	29	Dunman.
4.	Wonderkloof to Boschjespan	39	Ley.
5.	Boschjespan to Platkop	25	Ley.
6.	Platkop to Luipersrand (part)	18	Ley.
7.	Driebaden to Fauresmith	21	Dunman.
8.	Fauresmith to Lockshoek	19	Ley.
9.	Lockshoek to De Put	40	Ley.
10.	Lemoenfontein to Koesberg, *viâ* Smithfield and Rouxville	65	Ley.
11.	Koesberg to Gobo-Gobo	26	Dunman.
12.	Gobo-Gobo to Jammersberg	20	Ley.

S. B. MORGENROOD.

TABLES TO FACILITATE THE COMPUTATIONS.

Table O.

Separate Lengths of Bars.

Degrees Fah.	A.	B.	C.	D.	E.
	mm.	mm.	mm.	mm.	mm.
30	3047·3687	3047·3887	3047·4848	3047·4202	3047·3822
35	·4603	·4752	·4766	·5036	·4753
40	·5522	·5626	·5683	·5878	·5681
45	·6439	·6504	·6603	·6729	·6610
50	·7357	·7388	·7524	·7589	·7538
55	·8276	·8280	·8446	·8459	·8464
60	3047·9196	3047·9178	3047·9370	3047·9337	3047·9388
65	3048·0116	3048·0083	3048·0295	3048·0224	3048·0312
70	·1036	·0994	·1221	·1120	·1235
75	·1957	·1912	·2149	·2025	·2157
80	·2878	·2836	·3079	·2939	·3077
85	·3799	·3767	·4009	·3861	·3996
90	·4721	·4704	·4941	·4792	·4914
95	·5644	·5648	·5875	·5732	·5830
100	3048·6567	3048·6599	3048·6810	3048·6681	3048·6746

Table P.

Combined Lengths of Bars.

Degrees Fah.	Sum of Bars A, B, C, D, E.	Sum of Bars B, C, D, E.
	mm.	mm.
30	15237·0446	12189·6759
35	15237·3910	12189·9307
40	15237·8390	12190·2868
45	15238·2885	12190·6446
50	15238·7396	12191·0039
55	15239·1925	12191·3649
60	15239·6469	12191·7273
65	15240·1030	12192·0914
70	15240·5606	12192·4570
75	15241·0200	12192·8243
80	15241·4809	12193·1931
85	15241·9432	12193·5633
90	15242·4072	12193·9351
95	15242·8729	12194·3085
100	15243·3403	12194·6836

Table Q.

LOGARITHMS OF FACTORS DEPENDING ON THE RADII OF CURVATURE.

Lat.	Log. M.	Log. N.	Log. E.
° ′			
21 0	7·9961301	7·9935449	0·374220
10	1214	5420	208
20	1127	5391	197
30	1039	5362	185
40	0951	5332	173
50	0862	5303	161
22 0	7·9960773	7·9935273	0·374150
10	0683	5243	138
20	0592	5213	125
30	0501	5183	113
40	0410	5152	101
50	0318	5121	089
23 0	7·9960225	7·9935091	0·374077
10	0132	5060	064
20	7·9960039	5028	052
30	7·9959944	4997	039
40	9850	4965	026
50	9755	4934	014
24 0	7·9959659	7·9934902	0·374001
10	9563	4870	0·373988
20	9466	4837	975
30	9369	4805	962
40	9271	4773	949
50	9173	4740	936
25 0	7·9959075	7·9934707	0·373923
10	8975	4674	910
20	8876	4641	896
30	8776	4607	883
40	8675	4574	870
50	8574	4540	856
26 0	7·9958473	7·9934506	0·373843
10	8371	4472	829
20	8268	4438	816
30	8165	4404	802
40	8062	4370	788
50	7958	4335	774
27 0	7·9957854	7·9934300	0·373760
10	7749	4265	746
20	7644	4230	732
30	7538	4195	718
40	7433	4160	704
50	7326	4124	690
28 0	7·9957220	7·9934089	0·373676
10	7112	4053	661
20	7005	4017	647
30	6897	3981	633
40	6788	3945	618
50	6679	3908	604
29 0	7·9956570	7·9933872	0·373589
10	6460	3835	574
20	6350	3799	560
30	6240	3762	545
40	6129	3725	530
50	6017	3688	515

TABLES TO FACILITATE THE COMPUTATIONS—*continued.*

Table Q.—*continued.*

LOGARITHMS OF FACTORS DEPENDING ON THE RADII OF CURVATURE—*continued.*

Lat.	Log M.	Log N.	Log E.
° ′			
30 0	7·9955906	7·9933651	0·373501
10	5794	3618	486
20	5681	3576	471
30	5568	3538	456
40	5455	3501	440
50	5342	3463	425
31 0	7·9955228	7·9933425	0·373410
10	5114	3387	395
20	4999	3348	380
30	4884	3310	364
40	4769	3272	349
50	4653	3233	334
32 0	7·9954537	7·9933195	0·373318
10	4421	3156	303
20	4305	3117	287
30	4188	3078	271
40	4071	3039	256
50	3953	3000	240
33 0	7·9953835	7·9932960	0·373224

Table R.

LOGARITHMS OF FACTORS DEPENDING ON THE RADII OF CURVATURE AND ON FUNCTIONS OF THE LATITUDE.

Lat.	Log *k*.	Log F.	Log G.	Log H.	Log J.	Log P.	Log O.
° ′							
21 0	5·059795	4·440	4·09107	4·62168	5·0176	4·7338	9·6784
10	783	·442	·09484	·61793	·0182	·7317	·6844
20	772	·444	·09859	·61420	·0187	·7297	·6904
30	760	·446	·10232	·61048	·0193	·7277	·6963
40	748	·448	·10602	·60680	·0200	·7258	·7022
50	736	·451	·10969	·60314	·0207	·7240	·7080
22 0	5·059725	4·454	4·11334	4·59949	5·0214	4·7222	9·7138
10	713	·456	·11697	·59588	·0220	·7204	·7196
20	700	·458	·12058	·59228	·0227	·7186	·7252
30	688	·460	·12417	·58870	·0233	·7168	·7308
40	676	·462	·12774	·58515	·0240	·7151	·7364
50	664	·465	·13129	·58162	·0247	·7134	·7419
23 0	5·059652	4·468	4·13482	4·57809	5·0253	4·7117	9·7473
10	639	·470	·13833	·57460	·0260	·7101	·7527
20	627	·472	·14182	·57113	·0266	·7085	·7580
30	614	·475	·14529	·56766	·0273	·7069	·7633
40	601	·478	·14874	·56423	·0279	·7054	·7686
50	589	·481	·15217	·56082	·0286	·7039	·7738
24 0	5·059576	4·484	4·15558	4·55740	5·0292	4·7024	9·7789
10	563	·486	·15898	·55402	·0299	·7010	·7840
20	550	·488	·16236	·55065	·0306	·6996	·7890
30	537	·490	·16572	·54729	·0313	·6982	·7940
40	524	·493	·16907	·54397	·0321	·6968	·7990
50	511	·496	·17240	·54065	·0329	·6955	·8039

Table R.—*continued.*

LOGARITHMS OF FACTORS DEPENDING ON THE RADII OF CURVATURE AND ON FUNCTIONS OF THE LATITUDE—*continued.*

Lat. ° ′	Log *k*.	Log F.	Log G.	Log H.	Log J.	Log P.	Log C.
25 0	5·059498	4·499	4·17571	4·53734	5·0336	4·6942	9·8087
10	485	·501	·17901	·53406	·0344	·6929	·8135
20	471	·503	·18230	·53079	·0352	·6917	·8183
30	458	·506	·18557	·52753	·0359	·6905	·8230
40	445	·509	·18882	·52429	·0367	·6893	·8277
50	431	·512	·19205	·52108	·0375	·6881	·8324
26 0	5·059418	4·515	4·19526	4·51787	5·0383	4·6869	9·8370
10	404	·517	·19846	·51468	·0391	·6858	·8416
20	391	·519	·20165	·51150	·0399	·6847	·8460
30	377	·522	·20483	·50833	·0406	·6836	·8504
40	363	·525	·20800	·50518	·0415	·6826	·8548
50	349	·528	·21115	·50205	·0423	·6816	·8592
27 0	5·059335	4·531	4·21429	4·49892	5·0432	4·6806	9·8635
10	321	·533	·21742	·49581	·0440	·6796	·8678
20	307	·536	·22053	·49272	·0449	·6787	·8721
30	293	·539	·22363	·48964	·0457	·6778	·8763
40	279	·542	·22671	·48657	·0465	·6769	·8805
50	265	·545	·22978	·48352	·0473	·6760	·8846
28 0	5·059251	4·548	4·23284	4·48047	5·0481	4·6751	9·8887
10	236	·550	·23588	·47744	·0490	·6743	·8928
20	222	·553	·23891	·47442	·0499	·6735	·8968
30	208	·556	·24193	·47140	·0508	·6727	·9008
40	193	·559	·24495	·46840	·0517	·6719	·9048
50	179	·562	·24796	·46541	·0525	·6712	·9087
29 0	5·059164	4·565	4·25096	4·46243	5·0533	4·6705	9·9126
10	149	·567	·25395	·45947	·0543	·6698	·9164
20	135	·570	·25692	·45651	·0553	·6691	·9202
30	120	·573	·25988	·45356	·0563	·6684	·0240
40	105	·576	·26283	·45063	·0572	·6678	·9277
50	090	·579	·26577	·44771	·0582	·6672	·9324
30 0	5·059076	4·582	4·26870	4·44479	5·0591	4·6666	9·9351
10	061	·585	·27162	·44189	·0600	·6660	·9387
20	046	·588	·27453	·43899	·0610	·6655	·9423
30	031	·591	·27743	·43610	·0619	·6650	·9459
40	015	·594	·28032	·43323	·0629	·6645	·9494
50	5·059000	·597	·28320	·43036	·0639	·6640	·9529
31 0	5·058985	4·600	4·28607	4·42750	5·0649	4·6635	9·9564
10	970	·603	·28893	·42465	·0658	·6631	·9598
20	955	·606	·29178	·42181	·0668	·6627	·9633
30	939	·609	·29463	·41897	·0678	·6623	·9666
40	924	·612	·29747	·41616	·0689	·6619	·9699
50	909	·615	·30031	·41334	·0699	·6615	·9732
32 0	5·058893	4·618	4·30314	4·41053	5·0710	4·6612	9·9765
10	878	·621	·30596	·40774	·0721	·6609	·9798
20	862	·624	·30877	·40494	·0731	·6606	·9830
30	846	·627	·31157	·40215	·0742	·6603	·9861
40	831	·630	·31436	·39938	·0753	·6600	·9893
50	815	·633	·31714	·39662	·0764	·6597	·9924
33 0	5·058799	4·636	4·31991	4·39385	5·0775	4·6595	9·9955

Table S.

DISTANCES FROM THE 25TH PARALLEL OF LATITUDE.

Lat.	Distance.	Lat.	Distance.
° ′	Eng. Feet.	° ′	Eng. Feet.
21 0	— 1453253·17	26 0	+ 363433·57
5	— 1422984·50	5	+ 393721·99
10	— 1392715·52	10	+ 424010·77
15	— 1362446·24	15	+ 454299·90
20	— 1332176·66	20	+ 484589·39
25	— 1301906·77	25	+ 514879·24
30	— 1271636·58	30	+ 545169·45
35	— 1241366·08	35	+ 575460·02
40	— 1211095·27	40	+ 605750·94
45	— 1180824·15	45	+ 636042·23
50	— 1150552·73	50	+ 666333·87
55	— 1120280·99	55	+ 696625·88
22 0	— 1090008·95	27 0	+ 726918·26
5	— 1059736·59	5	+ 757211·00
10	— 1029463·91	10	+ 787504·11
15	— 999190·92	15	+ 817797·58
20	— 968917·62	20	+ 848091·42
25	— 938644·00	25	+ 878385·62
30	— 908370·07	30	+ 908680·19
35	— 878095·82	35	+ 938975·13
40	— 847821·24	40	+ 969270·44
45	— 817546·35	45	+ 999566·12
50	— 787271·14	50	+ 1029862·17
55	— 756995·60	55	+ 1060158·59
23 0	— 726719·75	28 0	+ 1090455·38
5	— 696443·57	5	+ 1120752·55
10	— 666167·07	10	+ 1151050·09
15	— 635890·24	15	+ 1181348·01
20	— 605613·08	20	+ 1211646·30
25	— 575335·60	25	+ 1241944·97
30	— 545057·79	30	+ 1272244·01
35	— 514779·65	35	+ 1302543·43
40	— 484501·17	40	+ 1332843·23
45	— 454222·36	45	+ 1363143·41
50	— 423943·23	50	+ 1393443·97
55	— 393663·76	55	+ 1423744·91
24 0	— 363383·95	29 0	+ 1454046·23
5	— 333103·81	5	+ 1484347·94
10	— 302823·34	10	+ 1514650·02
15	— 272542·53	15	+ 1544952·49
20	— 242261·39	20	+ 1575255·35
25	— 211979·91	25	+ 1605558·59
30	— 181698·08	30	+ 1635862·22
35	— 151415·92	35	+ 1666166·23
40	— 121133·42	40	+ 1696470·63
45	— 90850·58	45	+ 1726775·41
50	— 60567·40	50	+ 1757080·59
55	— 30283·87	55	+ 1787386·15
25 0	0·00	30 0	+ 1817692·10
5	+ 30284·22	5	+ 1847998·44
10	+ 60568·77	10	+ 1878305·17
15	+ 90853·68	15	+ 1908612·30
20	+ 121138·93	20	+ 1938919·81
25	+ 151424·53	25	+ 1969227·72
30	+ 181710·48	30	+ 1999536·02
35	+ 211996·78	35	+ 2029844·72
40	+ 242283·43	40	+ 2060153·81
45	+ 272570·44	45	+ 2090463·30
50	+ 302857·80	50	+ 2120773·18
55	+ 333145·51	55	+ 2151083·46

TABLES TO FACILITATE THE COMPUTATIONS—*continued.*

Table S—*continued.*

DISTANCES FROM THE 25TH PARALLEL OF LATITUDE—*continued.*

Lat.		Distance.	Lat.		Distance.
°	′	Eng. Ft.	°	′	Eng. Ft.
31	0	+ 2181394·14	32	0	+ 2545153·51
	5	+ 2211705·22		5	+ 2575469·41
	10	+ 2242016·69		10	+ 2605785·72
	15	+ 2272328·57		15	+ 2636102·43
	20	+ 2302640·84		20	+ 2666419·55
	25	+ 2332953·52		25	+ 2696737·08
	30	+ 2363266·59		30	+ 2727055·01
	35	+ 2393580·07		35	+ 2757373·35
	40	+ 2423893·95		40	+ 2787692·10
	45	+ 2454208·24		45	+ 2818011·26
	50	+ 2484522·92		50	+ 2848330·83
	55	+ 2514838·01		55	+ 2878650·81
			33	0	+ 2908971·20

Table T.

ASTRONOMICAL OBSERVATIONS AND RESULTS.

FINAL RESULTS OF ASTRONOMICAL AZIMUTHS.

Station No.	Station.	Approximate Latitude.	Approximate Longitude.	Astronomical Azimuth of Mark.	Angle between Mark and Station of Reference.	Astronomical Azimuth of Station of Reference.	Seconds of Geodetic Azimuth.	Difference. A — G.	Observer.
		° ′	H. M.	° ′ ″	° ′ ″	° ′ ″	″	″	
245	South End Hoouts River Base.. ..	S. 23 51	E. 1 57	0 0 0·30	N. End Base. 198 35 51·09	198 35 51·39 ±0·18	52·09	—0·70	S.
94	North End Ottoshoop Base	S. 25 39	E. 1 44	0 0 8·39	S. End Base. 19 46 39·65	340 13 28·74 ±0·20	25·38	+3·36	M.
77	South End Belfast Base	S. 25 40	E. 2 0	179 59 2·81	N. End Base. 0 45 12·12	180 44 14·93 ±0·17	17·37	—2·44	M.
96	Observatory Hill, Johannesburg ..	S. 26 11	E. 1 52	180 0 2·17	Cable Hill. 9 35 57·51	189 35 59·68 ±0·18	59·39	+0·29	M.
215	Driekuil..	S. 26 45	E. 1 44	359 59 51·74	Karreekuil. 55 5 34·33	55 5 26·07 ±0·16	20·61	+5·46	M.
106	Boschrand	S. 27 44	E. 1 49	359 59 42·62	Doornkop. 123 32 51·71	236 26 50·91 ±0·13	48·51	+2·40	M.
134	Orange River	S. 29 40	E. 1 37	359 59 37·39	Bestерskop. 0 42 27·41	0 42 4·80 ±0·13	6·40	—1·60	M.
122	North End Wepener Base	S. 29 44	E. 1 48	359 58 57·03	S. End Base. 16 42 35·60	343 16 21·43 ±0·16	18·17	+3·26	S.
9	Cwecweni	S. 31 52	E. 1 52	0 0 22·20	Xuka. 177 20 32·46	177 20 54·66 ±0·15	59·74	—5·08	S.

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—South End Houts River Base { latitude 23° 51′ S. / longitude 1h. 57m. E.

No. 245.

Instrumental constants { Rev. of S.T. Mic. 90″·22 / Div. of S. Level 1·20

Dates—1905, June 27, 28, 29.

Meridian Mark to S.

Reading of Coll. Centre { June 27 .... 5·128 / „ 28 .... 5·109 / „ 29 .. . 5·132

Observer—S.

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L.	Declination.	H. M.	June 27.	June 28.	June 29.
			° ′		s.	s.	s.
1	1540	U	85 18	13 25	40·75	40·55	40·35
	211	L	77 6	1 32	55·82	55·92	56·02
2	233	L	85 14	1 42	34·88	35·09	35·30
	1584	U	82 12	13 43	38·59	38·47	38·36
3	272	L	85 12	14 2	32·29	32·48	32·69
	1651	U	83 14	2 11	49·92	49·79	49·67
4	346	L	79 31	2 33	..	32·99	..
5	355	L	86 9	2 34	21·84	..	22·28
	1704	U	87 46	14 41	43·72	43·37	43·08
6	372	L	85 25	2 46	..	..	55·78
7	1734	U	82 40	14 48	24·07	..	23·88
	404	L	88 33	2 59	55·89	..	..
8	407	L	79 21	3 10	37·14	37·22	37·29
9	1808	U	84 9	15 21	34·78	34·68	34·58
	452	L	78 40	3 33	18·02	18·09	18·15
10	1878	U	77 45	15 46	49·00	48·96	48·93
11	516	L	85 33	3 59	33·54	33·66	33·78
	1920	U	78 28	16 6	17·68	17·65	17·62
12	548	L	80 26	4 24	12·88	..	..
13	1964	U	86 11	16 25	49·86	49·76	49·68
14	553	L	81 48	4 29	..	9·96	10·02
	567	L	83 6	4 33	38·07	..	..
15	595	L	83 40	4 49	26·63	26·68	..
	S*9148	U	82 11	16 50	13·21	13·19	..
16	2060	U	87 18	17 9	17·36	17·30	..
	626	L	82 36	5 9	26·26	26·29	..
17	2090	U	80 46	17 13	..	53·04	..
18	648	L	83 58	5 21	34·85	34·88	..
	2131	U	85 11	17 31	56·75	..	..
19	694	L	84 50	5 48	15·84	15·84	..
	2192	U	87 40	17 59	48·14	48·17	..

*S . . . Cape '80 Cat. (Stone).

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

South End Houts River Base—*continued.*

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	June 27.		June 28.		June 29.	
				s.		s.		s.
1	1540	13 25	W.	44·65	E.	50·12	E.	33·72
	211	13 32		52·59		48·58		50·07
2	233	13 42	W.	29·62	E.	22·74	E.	27·96
	1584	13 48		39·44		44·01		35·33
3	272	14 2	W.	27·70	E.	17·12	E.	25·32
	1651	14 11		50·91		56·86		47·29
4	346	14 33	E.	..	W.	29·95	W.	..
5	355	14 34		11·32		..		12·72
	1704	14 41		60·93		44·40		49·21
6	372	14 46	E.	..		..	W.	47·44
7	1734	14 48		28·03		..		22·74
	404	14 59		26·69		..		..
8	407	15 10	E.	32·35	W.	34·58	W.	31·65
9	1803	15 21	E.	41·60 41·30	W.	33·56 33·03	W.	34·08 33·75
	452	15 33		13·25		15·39		12·29
10	1878	15 46	E.	50·44	W.	47·02	E.	47·93
11	516	15 59	E.	25·10 24·60	W.	31·43 30·86	E.	21·44 20·56
	1920	16 6		19·01		15·77		16·80
12	548	16 24	E.	8·07	W.	..	W.	..
13	1964	16 25		57·60 57·92		49·41		55·78
14	553	16 29	E.	..		7·12		1·52
	567	16 35		31·80		..		..
15	595	16 49	W.	22·28	E.	13·33		..
	S 9148	16 50		13·65		13·56		..
16	2060	17 9	W.	21·54	E.	39·40		..
	626	17 9		22·32		14·92		..
17	2090	17 13	W.	..	E.	57·92		..
18	648	17 21		31·35		21·89		..
	2131	17 31		57·68		..		
19	694	17 48	W.	11·69	E.	0·56		..
	2192	17 59		52·56		74·01		.. ..

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

South End Houts River Base—*continued.*

Readings of Mark and Level (in seconds of arc).

Stars' No. in Cape 90.	June					
	27.		28.		29.	
	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.		rev.	"	rev.	"
1540 211	5·068	−0·80 +0·30	5·262	−1·62 −1·92	5·205	+3·75 +4·50
233 1584	5·069	+1·20 +1·84	5·271	−3·36 −3·90	5·205	+4·66 +4·26
272 1651	5·074	+2·20 +1·42	5·284	−4·20 −4·50	5·202	+3·76 +3·18
346 1704	..	.. ..	5·085	+0·95 +1·84	..	.. ..
355 1704	5·207	−4·04 −4·61	..	.. ..	5·055	+0·40 +1·86
372 1734	..	.. ..	..	.. ..	5·061	+2·90 +3·48
1734 404	5·216	−5·13 −5·60	..	.. ..	..	.. ..
407 1803	5·220	−5·91 −6·09	5·087	+1·89 +2·60	5·065	+3·33 +2·40
1803 452	5·221	−6·35 −6·69	5·088	+2·76 +2·37	5·067	+2·52 +3·66
1878 516	5·222	−1·50 −2·10	5·093	+2·46 +3·04	5·243	−1·64 −1·53
516 1920	5·223	−1·95 −1·20	5·097	+3·45 +3·68	5·243	−1·49 −1·53
548 1964	5·219	−0·93 −1·29	..	.. ..	..	.. ..
1964 553	..	.. ..	5·088	+3·45 +2·78	5·055	−1·02 −1·04
1964 567	5·216	−1·62 −2·00	..	.. ..	..	.. ..
595 S 9148	5·074	+2·10 +2·52	5·302	+1·16 +0·04	..	.. ..
2060 626	5·078	+2·02 +2·10	5·308	−0·76 −1·26	..	.. ..
2090 648	..	.. ..	5·296	−1·50 −1·47	..	.. ..
648 2181	5·081	+2·55 +3·84	..	.. ..	..	.. ..
694 2192	5·086	+4·65 +4·95	5·291	−1·65 −2·61	..	.. ..

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

South End Houts River Base—*concluded.*

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	June 27.	June 28.	June 29.
1540 211	+0″·75	+1″·15	−1″·32
233 1584	+0·24	−1·29	−0·83
272 1651	+0·14	+0·06	−1·08
346 1704	..	+0·45	..
355 1704	+1·81	..	−0·26
372 1734	..	..	−0·29
1734 404	+0·84	..	..
407 1803	+1·36	+0·43	+0·38
1803 452	+1·00	+0·15	+0·62
1878 516	−0·32	−0·17	−0·82
516 1920	−0·11	+1·04	+0·01
548 1964	+0·77	..	..
1964 553	..	+1·12	−2·86
1964 567	+1·08	..	..
595 S 9148	+0·68	+0·84	..
2060 626	+0·68	+0·81	..
2090 648	..	+0·93	..
648 2131	+0·31	..	..
694 2192	+2·00	+1·16	..
Means	+0·75	+0·51	−0·64

General Mean +0″·30.

Azimuth of Mark 0° 0′ 0″·30 ± 0″·18.

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—North End Ottoshoop Base { latitude 25° 39′ S. / longitude 1h. 44m. E.

No. 94.

Instrumental Constants { Rev. of S.T. Mic. 90″·16 / Div. of S. Level 1·20

Meridian Mark to S. 2 miles.

Dates—1904, June 13, 16, 17, 18.

Reading of Coll. Centre...... 9·955

Observer—M.

Reading of Centre Wire ...10·000

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L	Declination.	H. M.	June 13.	June 16.	June 17.	June 18.
			° ′		s.	s.	s.	s.
1	1584	U	82 11	13 48	34·09	33·80	33·68	33·55
	240	L	80 39	1 48	31·81	32·13	32·25	32·37
2	272	L	85 13	2 2	33·46	33·88	34·09	34·31
	1646	U	82 24	14 10	22·87	22·61	22·50	22·38
3	346	L	79 32	2 33	32·88	33·10	33·19	33·28
	1704	U	87 45	14 41	27·18	26·42	26·10	25·75
4	372	L	85 25	2 46	59·64	60·05	60·22	60·40
	1760	U	72 24	15 2	47·95	47·91	47·88	47·85

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	June 13.		June 16.		June 17.		June 18.	
				s.		s.		s.		s.
1	1584	13 48	W.	46·59	E.	48·41	E.	47·41	W.	39·09
	240	13 48		47·65		44·35		43·02		46·15
2	272	14 2	E.	50·60	W.	55·07	W.	52·57	E.	47·60
	1646	14 10		36·95		33·05		31·54		32·96
3	346	14 33	E.	48·49	W.	49·05	W.	48·01	E.	44·98
	1704	14 41		38·88		30·66		27·79		36·29
4	372	14 47	W.	22·86	E.	14·14	E.	16·14	W.	19·02
	1760	15 2		60·56		62·08		60·08		57·09

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

North End Ottoshoop Base—*concluded.*

Readings of Mark and Level (in divisions of striding level).

Stars' No. in Cape 90.	June 13. Mark.	June 13. Level.	June 16. Mark.	June 16. Level.	June 17. Mark.	June 17. Level.	June 18. Mark.	June 18. Level.
	rev.	div.	rev.	div.	rev.	div.	rev.	div.
1584 240	10·090	+0·87 +0·10	9·870	−2·62 −2·45	9·860	−6·00 −4·90	10·150	+3·30 +3·55
272 1646	9·882	−8·50 −8·00	10·112	+5·10 +5·65	10·140	+2·05 +2·80	9·819	−2·80 −3·50
346 1704	9·832	−8·15 −2·90	10·121	+3·65 +4·00	10·135	+2·50 +3·50	9·880	−3·65 −4·40
372 1760	10·138	+4·85 +6·50	9·840	−2·70 −4·20	9·807	−3·40 −4·70	10·146	+2·40 +2·15

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	June 13.	June 16.	June 17.	June 18.
	″	″	″	″
1584 240	+8·05	+ 8·88	+ 8·67	+8·95
272 1646	+6·28	+ 7.79	+ 9·55	+7·82
346 1704	+6·95	+10·71	+11·37	+7·85
372 1760	+8·03	+ 8·31	+ 6·88	+8·27
Means ..	+7·31	+ 8·91	+ 9·10	+8·22

General Mean + 8″·39.

Azimuth of Mark 0° 0′ 8″·39 ± 0″·20.

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—South End Belfast Base { Latitude 25° 40′ S.
Longitude 2h. 0m. E.

No. 77

Meridian Mark to N. 2 miles

Dates—1904, Feb. 4, 5, 11, 12.

Observer—M.

Instrumental Constants { Rev. of S.T. Mic. 90″·00
Div. of S. Level 1·50

Reading of Coll. Centre 9·990

Reading of Centre Wire 9·940

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L	Declination.	H. M.	February 4.	February 5.	February 11.	February 12.
			° ′		s.	s.	s.	s.
1	1958	L	87·24	16 24	51·28	51·72	..	..
	558	U	81·48	4 29	28·85	28·69	..	..
2	626	U	82·36	5 9	50·68	50·47	49·39	49·19
	2090	L	80·46	17 18	26·67	26·80	27·75	27·91
3	648	U	88·58	5 22	6·47	6·28	4·98	..
	2131	L	85·11	17 31	8·04	8·28	9·99	..
4	694	U	84·50	5 48	..	55·11	58·67	..
	2192	L	87·40	17 58	..	8·48	11·72	..
5	σ Oct.	L	89·14	19 4	59·40	..	68·06	69·52
	858	U	86·58	7 21	5·57	..	3·73	3·30
6	870	U	78·54	7 31	..	..	2·44	2·36
	2435	L	81·35	19 38	..	..	13·40	13·51
7	919	U	81·21	7 55	..	..	23·24	23·14
	2502	L	88·36	20 4	..	..	14·79	14·00

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	February 4.		February 5.		February 11.		February 12.	
				s.		s.		s.		s.
1	1958	4 25	W.	28·75	E.	27·74		..		..
	553	4 29		54·59		55·58		..		..
2	626	5 10	E.	17·00	W.	17·40	E.	26·50	W.	26·00
	2090	5 18		57·67		58·66		60·51		62·66
3	648	5 22	W.	30·23	E.	20·60	W.	38·15		..
	2131	5 31		48·50		44·88		46·88		..
4	694	5 49		..	W.	20·41	W.	22·24		..
	2192	5 58		..		47·48		61·93		..
5	σ Oct.	7 5	E.	57·99		..	E.	53·01	E.	39·93
	858	7 21		28·38		..		37·38		40·72
6	870	7 31		..		..	E.	35·88	E.	38·16
	2435	7 38		..		..		49·20		48.20
7	919	7 55		..		..	W.	53·64	W.	59·31
	2502	8 4		..		..		55·28		48·44

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

South End Belfast Base (*concluded*).

Readings of Mark and Level (in divisions of striding level).

Stars' No. in Cape 90.	February							
	4.		5.		11.		12.	
	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.	div.	rev.	div.	rev.	div.	rev.	div.
1958 558	10·500	+0·07 −0·02	9·485	−0·82 −1·00	..	.. ..	..	.. ..
626 2090	9·400	+0·05 −1·00	10·560	+0·52 −0·05	9·865	−0·85 −0·55	10·700	+0·80 +0·82
648 2181	10·495	+2·02 +1·82	9·477	+0·65 +0·20	10·681	−1·20 −0·70	..	.. ..
694 2192	..	.. ..	10·556	+0·95 +0·80	10·557	−1·05 −0·47	..	.. ..
σ Oct. 858	9·394	−0·27 −0·02	..	.. ..	9·425	−0·02 −0·25	9·379	+0·40 −0·12
870 2435	..	.. ..	..	.. ..	9·430	−0·32 −0·22	9·378	−0·47 −0·75
919 2502	..	.. ..	..	.. ..	10·568	+0·50 +1·10	10·712	−0·50 +1·85

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	February.			
	4.	5.	11.	12.
	″	″	″	″
1958 558	−52·99	−56·15	..	..
626 2090	−59·17	−57·29	−51·90	−61·16
648 2181	−53·48	−56·44	−61·61	..
694 2192	..	−57·04	−62·00	..
σ Oct. 858	−60·27	.	−58·19	−58·85
870 2435	..	..	−54·31	−54·27
919 2502	..	..	−62·21	−62·11
Means	−56·48	−56·78	−57·54	−57·85

General mean—57″·19.
Azimuth of Mark 359° 59′ 2″·81 ± 0·17.

Table T—*continued.*

Astronomical Observations and Results—*continued.*

Station—Observatory Hill, Johannesburg { Latitude 26° 11′ S.
Longitude 1h. 52m. E.

No. 96.

Meridian Mark to N. 1 mile.

Instrumental Constants { Rev. of S.T. Mic. 90″·20
Div. of S. Level 1·20

Dates—1904, April 19, 20, 21, 26, 27.
May 2, 3.

Reading of Coll. Centre { April 19, 20 ...... 9·813
" 21, 26, 27..
May 2, 3 ...... } 9·980

Observer—M.

Reading of Centre Wire { April 19, 20 ...... 9·980
" 21, 26, 27..
May 2, 3 ...... } 10·000

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L.	Declination.	H. M.	April					May	
					19.	20.	21.	26.	27.	2.	3.
			° ′		s.	s.	s.	s.	s.	s.	s.
1	1247	U	85 36	10 36	59·52	59·31	59·08	57·84	57·62	26·53	56·28
	2849	L	80 38	22 41	19·28	19·39	19·51	20·13	20·24	20·80	20·93
2	2882	L	80 0	23 0	27·52	27·62	27·73	28·27	28·37	28·86	28·97
	1300	U	85 14	11 7	51·28	51·12	50·94	49·94	49·76	48·89	48·70
3	2905	L	88 1	23 18	12·00	12·41	12·86	15·30	15·72	17·85	18·35
	1312	U	79 9	11 15	53·69	..	..	..	..	..	..
	1329	U	88 43	11 24	..	30·10	29·43	25·33	24·72	22·26	21·54
4	1345	U	84 57	11 35	..	33·94	33·81	33·01	32·85	32·17	32·01
	2974	L	86 26	23 46	..	1·37	..	..	..	..	..
	2975	L	82 33	23 46	..	..	17·67	18·28	18·38	18·82	18·94
5	1370	U	85 6	11 57	..	..	51·00	50·29	50·16	..	..
	8	L	86 34	0 2	..	..	59·64	..	..	..	..
	20	L	85 32	0 9	..	..	..	20·45	20·58	..	..
6	20	L	85 32	0 9	19·43	..	..	..	..	..	..
	1410	U	85 37	12 18	18·65	..	18·47	17·80	17·68	..	..
	79	L	86 14	0 39	..	..	12·39	13·07	13·19	..	..

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Observatory Hill, Johannesburg—*continued.*

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	April										May			
			19.		20.		21.		26.		27.		2.		3.	
				s.		s.		s.		s.		s.		s.		s.
1	1247	10 37	W.	54·77	W.	27·93	W.	28·27	E.	25·07	E.	22·57	W.	17·26	E.	16·24
	2849	10 41		36·27		49·00		46·51		41·59		41·23		37·34		35·19
2	2882	11 0	E.	55·44	E.	54·37	E.	54·36	W.	51·81	W.	51·91	E.	45·86	W.	46·50
	1300	11 8		25·28		25·44		21·82		14·18		10·18		9·82		2·51
3	2905	11 13	E.	27·57	E.	26·52	E.	31·80	W.	35·94	W.	39·90	E.	27·77	W.	40·48
	1312	11 16		26·22		..		..		..		..		..		..
	1329	11 24		..		20·35		66·44		54·89		39·05		49·27		25·15
4	1345	11 35		..	W.	63·69	W.	61·73	E.	59·60	E.	58·60	W.	51·40	E.	52·43
	2974	11 46		..		31·17		..		..		..		..		..
	2975	11 46		..		..		45·63		38·77		37·80		35·30		32·04
5	1370	11 58		..		..	W.	17·04	E.	17·63	E.	15·46		..		..
	8	12 3		..		..		29·37		..		..		..		..
	20	12 9		..		..		..		37·45		38·45		..		..
6	20	12 9	W.	22·39		..	E.	..	W.	..	W.	..		..		..
	1410	12 18		73·53		..		50·15		45·76		38·75		..		..
	79	12 39		..		..		34·91		33·43		38·08		..		..

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Observatory Hill, Johannesburg—*continued.*

Readings of Mark and Level (in Divisions of Striding Level).

Stars' No. in Cape 90.	April										May			
	19.		20.		21.		26.		27.		2.		3.	
	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.	div.	rev.	div.	rev.	div.	rev.	div.	rev.	div.	rev.	div.	rev.	div.
1247	10·154	+0·45	9·880	−5·20	9·949	+0·15	9·935	−0·15	9·941	−1·25	9·934	−0·12	9·924	−1·17
2849		+2·70		−4·65		0·00		−1·95		−0·70		−0·57		−1·62
2882	9·772	−2·20	9·783	0·00	9·951	−1·65	9·920	+0·35	9·928	−1·20	9·937	−1·47	9·918	+1·87
1300		−2·62		−1·40		−1·65		+0·20		−0·80		−1·77		+2·20
2905	9·762	+0·47	9·761	−0·70	9·955	−0·85	9·928	+0·05	9·934	+0·12	9·942	−1·45	9·900	+2·77
1312		−0·50		..		..		..		..		..		..
1329		..		−0·75		−2·15		+0·60		−0·10		−3·32		+1·50
1345	..	..	9·784	−1·25	9·935	+2·45	9·926	+1·50	9·937	0·00	9·910	−1·40	9·926	+0·32
2974		..		+2·30		..		..		..		..		..
2975		..		..		+2·57		+0·12		+0·72		−1·00		−1·00
1370	..	..	..	..	9·930	−0·30	9·912	−0·70	9·932	+0·35	..	..	..	..
8		..		..		−0·37		..		..		..		..
20		..		..		..		−1·12		−0·15		..		..
20	10·148	0·00	..	..	9·936	..	9·957	..	9·936	..	..	..	..	..
1410		0·00		..		+1·32		−1·22		−0·37		..		..
79		..		..		−0·15		−0·65		+0·20		..		..

Table T—*continued.*

Astronomical Observations and Results—*continued.*

Observatory Hill, Johannesburg—*concluded.*

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	April					May	
	19.	20.	21.	26.	27.	2.	3.
	″	″	″	″	″	″	″
1247 2849	+3·10	−3·01	+4·65	+0·29	−1·02	+7·39	−1·05
2882 1300	+0·30	+3·54	+0·13	+5·89	+0·90	−1·44	+2·97
2905 1312 1329	+3·58 ..	+2·80	+0·57	+7·05	+1·58	−1·36	+3·84
1845 2974 2975	..	+2·60 ..	+5·19	+0·80	+1·47	+7·67	+1·23
1870 8 20	..	..	+1·82 ..	+0·10	+0·51	..	..
20 1410 79	+3·06 ..	..	.. +1·58	.. +5·70	.. +1·28	..	..
Means	+2·51	+1·48	+2·32	+3·30	+0·78	+3·06	+1·75

General Mean + 2″·17.

Azimuth of Mark 180° 0′ 2″·17 ± 0″·18.

The concrete base was far from steady, and it was very difficult to ensure the accuracy of the readings of Level and Mark.

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—Driekuil { Latitude 26° 45′ S.
Longitude 1° 44′ E.

No. 215.

Instrumental { Rev. of S.T. Mic. 90″·36.
constants { Div. of S. Level 1·60.

Meridian Mark to S. 2¾ miles.

Reading of Coll. Centre ...... 9.980.

Dates—1905, Oct. 14, 15, 19.

Reading of Centre Wire......10·010.

Observer—M.

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L.	Declination.	H. M.	October		
					14	15	19
			° ′		s.	s.	s.
1	1188 2688	L U	80 31 89 18	9 36 21 44	39·53 10·42	39·65 8·80	40·11 2·60
2	1183 2777	L U	81 45 80 55	10 8 22 9	13·86 30·49	13·99 30·38	14·58 29·96
3	2786 1220	U L	86 27 89 2	22 18 10 15	52·06 31·91	.. ..	.. ..
4	1220 2805	L U	89 2 60 32	10 15 22 22	.. ..	32·99 38·10	37·17 38·00
5	1238 2849	L U	81 26 80 37	10 32 22 41	21·55 38·29	21·66 38·20	22·14 37·84
6	1287 2889	L U	84 5 81 26	10 59 23 4	54·02 22·79	54·17 22·70	54·78 22·34
7	2905 1829	U L	88 0 88 48	23 14 11 22	25·65 45·37	25·26 45·96	28·68 48·48
8	2987 1845	U L	77 54 84 58	23 27 11 35	.. ..	17·01 10·77	16·79 11·24
9	2975 1870	U L	82 33 85 6	23 46 11 57	.. ..	40·05 27·50	39·72 28·04

Table T—*continued.*

Astronomical Observations and Results—*continued.*

Driekuil—*continued.*

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	October					
			14.		15.		19.	
				s.		s.		s.
1	1188 2688	21 36 21 44	E.	46·87 63·15	W.	49·44 26·60	E.	50·94 40·99
2	1183 2777	22 8 22 9	W.	21·18 44·83	E.	19·99 44·55	W.	26·55 43·56
3	2786 1220	22 14 22 15	W.	10·44 15·48	..	.. ..	..	.. ..
4	1220 2805	22 15 22 22	..	.. ..	E.	11·13 49·62	W.	47·38 51·17
5	1288 2849	22 32 22 41	E.	28·95 51·67	W.	81·58 49·97	E.	85·14 51·17
6	1287 2889	23 0 23 4	E.	0·56 86·24	W.	4·17 88·87	E.	6·70 86·18
7	2905 1829	23 14 23 22	W.	52·89 83·64	E.	48·81 84·72	W.	87·79 0·16
8	2987 1845	23 27 23 35	..	.. ..	E.	29·79 16·09	W.	29·91 24·99
9	2975 1370	23 46 23 57	..	.. ..	W.	51·52 86·10	E	53·87 87·91

Readings of Mark and Levels (in divisions of striding Level).

Stars' No. in Cape 90.	October					
	14.		15.		19.	
	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.	div.	rev.	div.	rev.	div.
1188 2688	10·165	—0·40 —0·45	9·886	+0·55 +0·05	10·129	—0·65 —1·20
1188 2777	9·828	—1·95 —1·80	10·162	+0·15 0·00	9·889	—0·55 —0·55
2786 1220	9·822	—1·40 —1·00	..	.. ..	..	.. ..
1220 2805	..	..	10·170	+0·45 —1·40	9·882	—0·75 —1·70
1288 2849	10·164	—0·82 —0·65	9·875	—1·00 —0·50	10·091	—0·65 —1·00

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Driekuil—*concluded.*

Readings of Mark and Levels (in divisions of striding level)—continued.

Stars' No. in Cape 90.	October					
	14.		15.		19.	
	Mark.	Level.	Mark.	Level.	Mark.	Lovel.
	rev.	div.	rev.	div.	rev.	div.
1287 2889	10·163	−0·70 −0·60	9·877	+0·35 +0·10	10·081	−0·85 −1·05
2905 1829	9·835	−3·00 −2·40	10·152	−0·95 −0·90	9·902	−0.50 +0·50
2987 1845	..	.. ..	10·152	−0·90 −1·80	9·898	−0·25 +0·50
2975 1870	..	.. ..	9·879	−0·85 −0·50	10·112	−0·40 −1·00

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	October		
	14.	15.	19.
	″	″	″
1188 2688	− 8·71	−7·17	−9·50
1183 2777	− 7·21	−6·29	−6·92
2786 1220	− 7·71	..	..
1220 2805	..	−8·07	−9·40
1238 2849	− 9·65	−7·86	−10·61
1287 2889	−10·26	−8·18	−8·32
2905 1829	− 6·70	−8·68	−6·75
2987 1845	..	−8·98	−8·20
2975 1870	..	−7·44	−9·09
Means	− 8·88	−7·83	−8·60

General Mean — 8″·26
Azimuth of Mark 359° 59′ 51″·74 ± 0″·16

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—Boschrand { Latitude 27° 44′ S.
Longitude 1h. 49m. E.

No. 106.

Instrumental Constants { Rev. of S.T. Mic. 90″·36
Div. of S. Level 1·60

Meridian Mark to S. 1½ miles.

Reading of Coll. Centre 9·980

Dates—1905, Aug. 28, 30, 31, Sept. 3.

Observer—M.

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L.	Declination.	R. M.	August 28.	August 30.	August 31.	Sept. 3.
			° ′		s.	s.	s.	s.
1	2139	U	83 12	17 35	18·11	17·78	..	..
	684	L	80 33	5 44	36·75	36·99	..	..
2	2192	U	87 40	17 59	35·10	34·18	..	32·14
	721	L	85 56	6 4	34·46	34·99	..	36·16
3	2280	U	84 8	18 37	57·72	57·42	57·24	56·68
	784	L	80 48	6 47	50·89	51·10	51·21	51·57
4	811	L	79 17	7 2	29·30	29·47	..	29·86
	2304	U	89 15	19 9	56·98	54·79	..	49·58
5	2370	U	81 57	19 16	33·50	33·32	33·21	32·84
	858	L	86 53	7 19	57·68	58·18	58·47	59·42
6	870	L	78 54	7 30	46·80	46·94	47·02	47·28
	2485	U	81 35	19 38	43·95	43·80	43·71	43·38
7	919	L	81 21	7 55	1·51	1·67	1·75	2·05
	2502	U	88 36	20 4	54·15	53·99	53·89	53·51
8	2531	U	84 44	20 20	19·08	18·91	18·80	18·39
	979	L	80 36	8 29	53·07	53·18	53·24	53·46
9	1006	L	86 14	8 38	5·41	..	5·75	6·27
	2612	U	85 35	20 55	19·38	..	19·17	18·79
10	2650	U	85 13	21 11	58·93	..	..	..
	1105	L	84 15	9 25	40·82	..	..	..

Table T—*continued*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Boschrand—*continued.*

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	August						Sept. 3.	
			28.		30.		31.			
				s.		s.		s.		s.
1	2139 684	17 35 17 41	W.	36·42 55·64	E.	34·98 56·98		.. ..		.. ..
2	2192 721	17 59 18 4	E.	54·54 51·19	W.	50·91 53·89		.. ..	E.	51·26 53·53
3	2280 784	18 38 18 48	E.	16·62 7·94	W.	14·97 10·22	W.	15·75 9·36	W.	15·09 10·08
4	811 2304	19 2 19 10	W.	47·23 19·65	E.	48·06 7·59		.. ..	W.	48·61 8·73
5	2370 858	19 16 19 20	W.	51·07 17·45	E.	50·65 17·03	E.	51·01 17·61	E.	50·82 18·47
6	870 2435	19 31 19 39	E.	3·27 3·14	W.	5·38 2·83	W.	5·37 2·27	E.	5·21 1·82
7	919 2502	19 55 20 5	E.	17·47 18·80	W.	20·44 11·64	E.	19·31 11·98	W.	19·82 11·58
8	2531 979	20 20 20 30	W.	36·63 10·20	E.	37·60 9·50	E.	37·89 9·44	W.	36·39 10·33
9	1006 2612	20 38 20 55	W.	25·02 36·93		.. ..	W.	26·08 36·15	E.	21·32 39·71
10	2650 1105	21 12 21 25	E.	19·83 57·78		.. ..		.. ..		.. ..

Readings of Mark and Levels (in divisions of striding level).

Stars' No. in Cape 90.	August						Sept. 3.	
	28.		30.		31.			
	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.	div.	rev.	div.	rev.	div.	rev.	div.
2139 684	9·805	−0·40 −0·80	10·166	+0·70 −0·20	..	.. ..	..	.. ..
2192 721	10·194	+0·02 −0·25	9·804	−0·62 +0·50	..	.. ..	10·188	+0·10 −0·35
2280 784	10·196	−0·30 −0·25	9·807	+0·67 +0·50	9·798	−1·40 +0·20	9·796	−0·80 −0·50
811 2304	9·806	−1·37 −1·20	10·164	+1·10 +0·70	..	.. ..	9·797	−0·10 −0·30
2370 858	9·808	−0·70 −0·70	10·178	+0·70 +0·85	10·179	−0·85 −0·80	10·181	−0·10 −0·25

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Boschrand—*concluded.*

Readings of Mark and Levels (in divisions of striding levels)—continued.

Stars' No. in Cape 90.	August 28. Mark.	August 28. Level.	August 30. Mark.	August 30. Level.	August 31. Mark.	August 31. Level.	Sept. 3. Mark.	Sept. 3. Level.
	rev.	div.	rev.	div.	rev.	div.	rev.	div.
870 2485	10·207	+0·07 −0·52	9·814	−0·27 +0·20	9·808	−0·30 0·00	10·176	−0·55 −0·60
919 2502	10·209	−1·25 −0·60	9·813	+0·40 −0·05	10·175	−0·55 −0·55	9·798	−0·55 −0·60
2531 979	9·810	−0·60 −0·25	10·182	+0·90 +0·80	10·177	−0·65 −1·27	9·799	−0·70 −0·50
1006 2612	9·817	+0·02 −0·70	..	.. ..	9·818	−0·40 −0·20	10·197	−0·20 −0·35
2650 1105	10·211	−0·77 −1·12	..	.. ..	..	.. ..	..	.. ..

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	August 28.	August 30.	August 31.	Sept. 3.
	″	″		
2139 681	−17·20	−20·04	..	..
2192 721	−18·55	−17·40	..	−17·92
2284 784	−18·07	−17·10	−17·58	−17·66
811 2304	−16·01	−17·53	..	−17·01
2370 858	−17·91	−18·40	−19·87	−19·36
870 2485	−17·25	−15·85	−15·62	−17·85
919 2502	−17·64	−16·51	−17·81	−16·92
2531 979	−15·64	−15·51	−15·93	−16·07
1006 2612	−16·58	..	−17·66	−16·67
2650 1105	−18·89	..	..	..
Means ..	−17·37	−17·29	−17·41	−17·43

General Mean −17″·37.

Azimuth of Mark 359° 59′ 42″·63±0″·13.

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—Orange River { Latitude 29° 40′ S.
Longitude 1h. 37m. E.

No. 134.

Meridian Mark to S. 2 miles.

Dates—1905, Sept. 19, 20, 26.

Observer—M.

Instrumental constants { Rev. of S.T. Mic. 90″·36.
Div. of S. Level 1″·60

Reading of Coll. Centre ...... 9·980.

Reading of Centre Wire ...... 10·010.

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L.	Declination.	H. M.	September		
					19.	20.	26.
			° ′		s.	s.	s.
1	919 2502	L U	81 21 83 36	7 55 20 4	3·80 51·42	3·92 51·27	.. ..
2	2531 979	U L	84 44 80 36	20 20 8 29	15·99 54·85	15·81 54·96	.. ..
3	1006 2612	L U	86 14 85 35	8 38 20 55	9·46 16·47	9·70 16·29	11·08 15·28
4	2650 1105	U L	85 13 84 15	21 11 9 25	56·61 42·66	56·46 42·79	55·61 48·52
5	1138 2688	L U	80 31 89 18	9 36 21 44	37·18 39·27	37·25 38·37	37·69 38·45
6	1183 2777	L U	81 45 80 55	10 3 22 9	11·50 32·31	11·57 32·26	11·98 32·00
7	2786 1220	U L	86 27 89 2	22 18 10 15	56·81 14·48	56·68 14·81	55·98 17·54
8	1238 2849	L U	81 26 80 37	10 32 22 41	19·64 39·68	19·70 39·64	20·00 39·49

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Orange River—*continued.*

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	September 19.		September 20.		September 26.	
				s.		s.		s.
1	919 2502	19 55 20 4	E.	0·81 51·06	W.	4·63 48·60		. . . .
2	2581 979	20 20 20 29	W.	18·51 52·94	E.	15·87 52·77		. . . .
3	1006 2612	20 38 20 55	W.	9·67 14·41	E.	7·90 17·47	E.	15·02 21·79
4	2650 1105	21 11 21 25	E.	57·45 89·25	W.	58·21 48·90	W.	60·01 49·36
5	1188 2688	21 36 21 44	E.	34·40 54·57	W.	87·76 21·83	W.	43·26 27·98
6	1188 2777	22 8 22 9	W.	10·70 30·99	E.	10·39 32·88	E.	15·41 88·59
7	2786 1220	22 13 22 15	W.	54·55 15·94	E.	57·01 14·08	E.	68·99 12·77
8	1288 2849	22 32 22 41	E.	16·88 40·42	W.	20·72 88·28	W.	25·56 44·91

Readings of Mark and Levels (in divisions of striding level).

Stars' No. in Cape 90.	September 19.		September 20.		September 26.	
	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.	div.	rev.	div.	rev.	div.
919 2502	10·267	−0·62 −0·80	9·750	+1·57 +2·27	. .	. . . .
2581 979	9·751	−1·10 −0·85	10·244	−0·65 +0·15	. .	. . . .
1006 2612	9·754	−0·75 −0·77	10·245	−0·50 −0·62	10·235	−1·75 −2·60
2650 1105	10·252	−2·62 −2·97	9·752	+1·95 +1·80	9·752	0·00 0·00
1188 2688	10·251	−2·75 −2·85	9·750	+2·10 +2·82	9·755	−0·80 +1·00
1183 2777	9·754	−0·65 −0·40	10·247	−0·45 −0·07	10·247	−1·65 −1·60
2786 1220	9·754	−0·85 +0·10	10·246	+0·15 +0·32	10·246	−1·60 −1·15
1288 2849	10·251	−8·20 −8·32	9·748	+1·90 +2·17	9·740	+0·80 +1·00

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Orange River—*concluded.*

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	September		
	19.	20.	26.
	″	″	″
919 2502	—24·00	—22·99	..
2531 979	—22·41	—22·29	..
1006 2612	—22·82	—22·94	—23·10
2650 1105	—24·06	—22·58	—22·01
1188 2688	—23·45	—22·29	—21·96
1183 2777	—22·65	—22·27	—20·49
2786 1220	—21·59	—23·85	—22·57
1238 2849	—23·00	—22·59	—21·86
Means ..	—23·01	—22·72	—21·91

General Mean —22″·60.

Azimuth of Mark 359° 59′ 37″·40 ±0·13.

Table T—*continued.*

Astronomical Observations and Results—*continued.*

Station—North End Wepener Base {Latitude 29° 44′ S.
Longitude 1h. 48m. E.

No. 122.

Meridian Mark to S.

Rev. of S.T. Mic 90″·16

Dates—1905, March 6, 7, 8, 10, 11.

Div. of S. Level 1″·20

S. Stone's Catalogue, 1880.

Observer—S.

Reading of Coll. Centre
March 6...5·164
„ 7...5·152
„ 8...5·159
„ 10...5·155
„ 11...5·156

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L.	Declination.	H. M.	March 6.	March 7.	March 8.	March 10.	March 11.
			° ′		s.	s.	s.	s.	s.
1	2192	L	87 39	17 58	57·45	58·02	58·59	59·78	60·40
	721	U	85 56	6 4	54·96	54·63	54·30	53·73	53·40
2	S 9947	L	80 16	18 12	10·78	10·92	11·05	11·33	11·48
	S 3016	U	81 31	6 21	23·80	23·64	23·48	22·98	22·82
3	S 10171	L	80 50	18 33	18·43	18·58	18·72	19·00	19·15
	784	U	80 43	6 43	1·67	1·53	1·39	1·18	0·99
4	S 3401	U	82 47	6 56	51·42	..	..	50·74	50·56
5	S 3449	U	83 58	7 0	..	49·82	49·62	..	..
6	2304	L	89 14	19 7	14·39	15·98	17·57	20·84	22·55
7	S 3591	U	83 37	7 13	..	20·25	..	19·69	19·49
	858	U	86 53	7 20	37·39	..	36·64	35·90	35·51
8	2435	L	81 35	19 38	26·90	27·08	..	27·43	27·58
9	925	U	83 36	7 49	60·43	59·68	58·92	57·40	56·59
	2502	L	83 36	20 4	30·31	30·47	30·63	30·96	31·13
10	S 4289	U	81 20	8 14	49·64	..	49·41	49·16	49·07
11	S 10882	L	81 16	20 17	22·89	..	..	23·34	23·47
12	2536	L	81 36	20 22	9·08	9·19	9·31	..	..
13	979	U	80 37	8 30	7·85	7·75	7·65	..	7·35
	S 10999	L	80 28	20 35	..	..	13·55	..	13·85
14	S 4661	U	86 15	8 38	..	46·14	..	..	..
15	S 4663	U	82 14	8 41	58·37	..	58·15	..	57·81
16	2619	L	85 8	20 57	58·32	58·49	..	..	..
17	1064	U	85 17	9 10	..	52·44	52·29	51·99	..
18	2650	L	85 13	21 11	..	24·59	24·74	..	25·21
19	1107	U	80 23	9 27	..	..	..	29·04	28·98
20	1138	U	80 31	9 36	..	..	51·67	51·55	..
	2688	L	89 17	21 41	.	..	3·15	4·71	5·55

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

North End Wepener Base—*continued.*

Transits.

No. of Pair.	Stars' No. in Cape 90.	H. M.	March									
			6.		7.		8.		10.		11.	
				s.		s.		s.		s.		s.
1	2192 721	11 45 11 51	E.	51·00 39·20	W.	35·67 48·94	E.	49·86 39·78	W.	39·79 45·05	E.	47·01 41·76
2	S 9947 S 8016	11 58 12 8	E.	59·12 9·88	W.	55·89 14·50	E.	58·95 10·13	W.	57·90 11·73	E.	59·22 11·57
3	S 10171 784	12 25 12 34	E.	8·02 46·00	W.	3·76 52·68	E.	7·01 48·46	W.	6·44 49·63	E.	6·88 49·25
4	S 3401 2304	12 48 12 54	E.	34·36 35·80		.. ..		.. ..	W.	38·35 8·37	E.	38·72 4·81
5	S 3449 2304	12 47 12 53		.. ..	W.	41·99 24·66	E.	36·04 69·76		.. ..		.. ..
6	2304 S 3591	12 53 13 0		.. ..	W.	29·61 12·42		.. ..	W.	67·39 7·36	E.	67·49 7·80
7	2304 858	12 54 13 7	E.	35·45 16·34		.. ..	E.	11·51(*a*) 13·25(*b*) 23·00(*a*) 22·60(*b*)	W.	11·79 24·19	E.	11·42 24·62
8	2435 925	13 25 13 36	W.	14·08 44·86	E.	15·70 42·85		.. ..	E.	15·10 47·70	W.	16·76 39·52
9	925 2502	13 36 13 51	W.	42·84 18·23	E.	42·89 19·34	W.	52·77 17·50	E.	48·08 18·78	W.	38·86 21·38
10	S 4289 S 10882	14 1 14 4	W.	37·40 10·43		.. ..		.. ..	E.	37·53 10·89	W.	35·90 13·02
11	S 4289 2586	14 1 14 8		.. ..		.. ..	W.	37·62 56·45		.. ..		.. ..
12	2586 979	14 8 14 16	W.	56·47 54·54	E.	57·20 53·81		.. ..		.. ..		.. ..
13	979 S 10999	14 16 14 22		.. ..		.. ..	W.	54·90 1·12		.. ..	W.	53·15 3·55
14	S 4661 2619	14 25 14 44		.. ..	E.	31·46 42·62		.. ..		.. ..		.. ..
15	S 4663 2619	14 28 14 44	W.	46·06 41·58		.. ..		.. ..		.. ..		.. ..
16	S 4663 2650	14 28 14 58		.. ..		.. ..	W.	45·61 11·22		.. ..	W.	43·57 17·08
17	1064 2650	14 57 14 58		.. ..	E.	40·20 13·18		.. ..		.. ..		.. ..
18	1064 2688	14 57 15 27		.. ..		.. ..	W.	41·94 46·80	E.	36·72 65·90		.. ..
19	1107 2688	15 14 15 28		.. ..		.. ..		.. ..	E.	15·32 7·28	W.	15·76 28·56
20	1138 2688	15 23 15 27		.. ..		.. ..	W.	40·28 45·34	E.	38·03 66·07		.. ..

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

North End Wepener Base—*continued.*

Readings of Mark and Level (in seconds of arc).

Stars' No. in Cape 90.	March									
	6.		7.		8.		10.		11.	
	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.	Mark.	Level.
	rev.	"	rev.	"	rev.	"	rev.	"	rev.	"
2192 721	5·800	−8·50 −4·58	4·446	−6·82 −7·28	5·838	+0·56 −0·26	4·425	+0·76 +1·00	5·848	+0·14 −0·40
S 9947 S 8016	5·816	−2·57 −8·56	4·426	−7·55 −7·25	5·841	−0·92 −1·88	4·426	+1·48 +2·00	5·856	−1·08 −1·88
S 10171 784	5·818	+1·82 +1·88	4·420	−7·56 −8·85	5·841	−1·98 −2·84	4·485	+2·05 +1·88	5·858	−2·87 −2·46
S 8401 2804	5·806	+1·79 +1·88	..	.. ..	..	.. ..	4·439	+1·75 +1·80	5·841	−2·28 −1·80
S 8449 S 2804	..	.. ..	4·426	−9·92 −9·98	5·837	−2·61 −2·79	..	.. ..	..	.. ..
2804 S 8591	..	.. ..	4·429	−9·93 −9·95	..	.. ..	4·446	+2·22 +8·00	5·836	−1·67 −1·80
2804 858	5·794	+0·98 +0·44	..	.. ..	(*a*)5·832 (*b*)5·828	−2·82(*a*) −2·42(*b*) −2·67(*a*) −2·57(*b*)	4·458	+8·45 +8·45	5·834	−1·74 −1·85
2485 925	4·448	+5·18 +5·81	5·815	−2·75 −2·85	..	.. ..	5·842	−1·62 −2·71	4·496	+0·40 +0·68
925 2502	4·450	+5·69 +6·26	5·818	−8·21 −8·84	4·461	−0·81 +0·66	5·835	−8·68 −4·85	4·500	+1·05 +1·50
S 4289 S 10882	4·467	−0·68 −0·93	..	.. ..	..	.. ..	5·823	−4·58 −4·12	4·508	+1·95 +2·40
S 4289 2536	..	.. ..	..	.. ..	4·464	+1·29 +1·11	..	.. ..	..	.. ..
2586 979	4·477	−1·35 −1·50	5·818	−4·02 −3·96	..	.. ..	..	.. ..	..	.. ..
979 S 10999	..	.. ..	..	.. ..	4·468	+0·81 +0·41	..	.. ..	4·502	+2·64 +2·66
S 4661 2619	..	.. ..	5·816	−4·02 −4·19		.. ..	..	.. ..	..	.. ..
S 4668 2619	4·488	−2·42 −8·18	..	.. ..	..	.. ..	..	.. ..	..	.. ..
S 4668 2650	..	.. ..	..	.. ..	4·465	+0·15 +0·08	..	.. ..	4·498	+2·67 +1·50
1064 2650	..	.. ..	5·819	−8·86 −4·14	..	.. ..	..	.. ..	..	.. ..
1064 2688	..	.. ..	..	.. ..	4·461	+0·26 +0·87	5·808	+0·10 −0·78	..	.. ..
1107 2688	..	.. ..	..	.. ..	..	.. ..	5·806	−1·44 −1·29	4·505	+2·22 +1·77
1188 2688	..	.. ..	..	.. ..	4·455	−0·14 +0·74	5·820	−1·29 −0·90	..	.. ..

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

North End Wepener Base—*concluded.*

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	March				
	6.	7.	8.	10.	11.
2192 721	″ —62·09	″ —60·32	″ —64·00	″ —60·57	″ —61·06
S 9974 S 3016	—64·07	—61·85	—64·23	—62·00	—62·98
S 10171 784	—65·42	—62·79	—64·77	—62·64	—64·22
S 3401 2304	—67·20	..	..	—63·85	—61·91
S 3449 2304	..	—62·63	—64·12	..	..
2304 S 3591	..	—63·27	..	—62·68	—61·89
2304 858	—64·89	..	—63·97 —63·82	—61·67	—62·40
2435 925	—62·81	—63·73	..	—62·77	—61·71
925 2502	—63·30	—63·42	—61·16	—62·69	—61·59
S 4289 S 10882	—63·29	..	..	—61·99	—61·52
S 4289 2536	..	..	—60·90	..	..
2536 979	—62·67	—64·82	..	..	..
979 S 10999	..	..	—63·14	..	—63·38
S 4661 2619	..	—64·96	..	..	..
S 4663 2619	—63·37	..	..	..	..
S 4663 2650	..	..	—61·94	..	—63·94
1064 2650	..	—63·32	..	..	..
1064 2688	..	..	—61·69	—62·16	..
1107 2688	..	..	..	—63·00	—64·19
1138 2688	..	..	—62·14	—63·76	..
Means	—63·86	—63·11	—62·99	—62·48	—62·56

General Mean — 62″·97.

Azimuth of Mark 359° 58′ 57″·03 ± 0·16.

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Station—Cwecweni. { Latitude 31° 52′ S.
Longitude 1h. 52m. E.

No. 9.

Rev. of S.T. Mic. 90″·12.

Meridian Mark to S.

Div. of S. Level 1″·20.

Dates—1905.—May 21, 22.

Reading of Coll. Centre { May 21... 5·150
May 22... 5·167

Observer—S.

Right Ascensions.

No. of Pair.	Stars' No. in Cape 90.	U or L	Declination.	H. M.	May 21.	May 22.
			° ′		s.	s.
1	2688 1157	L U	89 17 85 35	21 42 9 45	.. ..	58·81 8·97
2	1183 2786	U L	81 46 86 27	10 8 22 13	.. ..	20·05 33·10
3	2786 1233	L U	86 27 86 5	22 13 10 28	.. ..	33·10 53·87
4	2849 1262	L U	80 37 80 8	22 41 10 44	.. ..	28·92 58·25
5	1287 2905	U L	84 5 88 0	11 0 23 13	.. ..	7·48 39·76
6	1304 2905	U L	85 43 88 0	11 10 23 13	.. ..	37·69 39·76
7	2905 1345	L U	88 0 84 58	23 13 11 35	.. ..	39·76 29·14
8	2990 1370	L U	82 41 85 7	23 52 11 57	.. ..	12·72 48·07
9	15 1397	L U	82 45 87 54	0 5 12 10	.. ..	35·23 29·46
10	29 1410	L U	88 53 85 38	0 11 12 18	.. ..	21·65 16·92
11	1410 29	U L	85 38 88 53	12 18 0 11	.. ..	16·92 21·65
12	76 1458	L U	85 56 84 37	0 38 12 45	.. ..	23·45 12·32
13	1540 211	U L	85 18 78 59	13 25 1 32	47·37 52·60	47·24 52·66
14	233 1584	L U	85 15 82 12	1 42 13 43	28·12 42·11	.. ..
15	1584 240	U L	82 12 80 39	13 43 1 48	.. ..	42·06 29·71
16	272 1634	L U	85 12 80 34	2 2 14 6	26·28 27·19	26·38 27·16
17	346 1704	L U	79 31 87 46	2 33 14 41	30·44 52·41	30·49 52.35
18	372 1734	L U	85 25 82 40	2 46 14 48	.. ..	50·90 26·33
19	407 1803	L U	79 21 84 9	3 10 15 21	.. ..	35·41 36·65

Table T—*continued.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*continued.*

Cwecweni—*continued.*

No. of Pair.	Stars' No. in Cape 90.	H. M.	*Transits.* May 21.		May 22.		*Readings of Mark and Levels (in seconds of arc).* May 21. Mark.	May 21. Level.	May 22. Mark.	May 22. Level.
				s.		s.	rev.	"	rev.	"
1	2688 1157	9 39 9 41		.. ..	W.	24·88 55·55	..	.. ..	5·852	+1·17 +1·15
2	1183 2786	10 0 10 10		.. ..	W.	5·18 11·08	..	.. ..	5·854	+1·48 +2·18
3	2786 1233	10 10 10 25		.. ..	W.	10·95 39·78	..	.. ..	5·849	+2·44 +2·81
4	2849 1262	10 38 10 41		.. ..	W.	10·78 42·86	..	.. ..	5·849	+2·18 +2·00
5	1287 2905	10 56 11 10		.. ..	E.	51·65 18·14	..	.. ..	4·958	+2·36 +2·36
6	1304 2905	11 7 11 10		.. ..	E.	22·58 17·56	..	.. ..	4·968	+1·90 +1·45
7	2905 1345	11 10 11 32		.. ..	E.	17·15 14·57	..	.. ..	4·963	+0·97 +0·97
8	2990 1370	11 48 11 54		.. ..	E.	53·92 83·02	..	.. ..	4·959	+1·26 +1·01
9	15 1397	12 2 12 7		.. ..	E.	16·59 17·69	..	.. ..	4·962	+0·62 +0·48
10	29 1410	12 7 12 15		.. ..	E.	56·81 2·18	..	.. ..	4·964	−0·09 −0·52
11	1410 29	12 15 12 7		.. ..	E.	2·80 56·60	..	.. ..	4·968	−0·82 −0·69
12	76 1458	12 35 12 41		.. ..	E.	8·25 57·58	..	.. ..	4·957	−0·84 −0·18
13	1540 211	13 22 13 29	E.	85·28 85·87	E.	81·65 85·11	4·927	−8·94 −4·26	4·955	+1·02 +0·90
14	238 1584	13 39 13 40	E.	8·57 28·62		.. ..	4·922	−4·45 −4·52	..	.. ..
15	1584 240	13 40 13 45		.. ..	W.	28·25 9·81	..	.. ..	5·846	−0·45 −0·50
16	272 1684	13 59 14 8	E.	6·55 18·71	W.	4·62 12·72	4·927	−4·88 −5·10	5·846	+0·18 +0·92
17	346 1704	14 30 14 88	W.	12·88 45·04	W.	11·52 44·01	5·857	−2·10 −1·44	5·889	+0·83 +1·80
18	372 1784	14 48 14 45		.. ..	W.	80·50 11·47	..	.. ..	5·889	+1·55 +1·86
19	407 1808	15 7 15 18		.. ..	W.	16·91 22·96	..	.. ..	5·345	+0·41 +0·41

Table T—*concluded.*

ASTRONOMICAL OBSERVATIONS AND RESULTS—*concluded.*

Cwecweni—*concluded.*

Resulting Azimuths of Mark.

Stars' No. in Cape 90.	May	
	21.	22.
	″	″
2688 1157	..	+21·06
1183 2786	..	+23·19
2786 1233	..	+22·46
2849 1262	..	+21·57
1287 2905	..	+22·66
1304 2905	..	+22·07
2905 1345	..	+22·24
2990 1370	..	+22·40
15 1397	..	+21·95
29 1410	..	+20·77
1410 29	..	+20·64
76 1458	..	+22·37
1540 211	+22·48	+21·40
233 1584	+22·98	..
1584 240	..	+24·12
272 1634	+22·84	+23·35
346 1704	+23·22	+22·01
372 1734	..	+20·93
407 1803	..	+21·61
Means ..	+22·88	+22·04

General Mean +22″·20.

Azimuth of Mark 0° 0′ 22″·20 ±0″·15.

Table U.

RESULTS OF LATITUDE OBSERVATIONS.

Station No.	Name of Station.	Height above M.S.L.	A Astronomical Latitude S.	No. of pairs observed.	No. of Nights.	p.e. of result from single pair ±	p.e. of a single declination ±	p.e. of resulting Latitude ±	G Seconds of Geodetic Latitude.	Difference A—G.	$\frac{\Sigma Z_s \backsim \Sigma Z_s}{\text{No. of pairs.}}$	Observer.	P.
		Eng. Ft.	° ′ ″			″	″	″	″	″	″		
248	Lejuma (T.)	5714	23 1 17·97	14	1	—	0·85	0·19	26·81	— 8·84	+ 48	S	—
247	Blaauwberg (T.)	6710	23 3 59·47	16	1	—	0·42	0·13	414·49	—15·02	— 98	S	—
243	Loskop II. (T.)	4679	23 29 7·14	14	1	—	0·53	0·14	7·92	— 0·78	+ 83	S	—
246	North End Houts River Base (T.) ..	3707	23 34 3·36	12	2	0·33	0·56	0·13	4·12	— 0·76	+101	S	—
241	Schnells Kop (T.)	6229	23 47 44·57	14	1	—	0·76	0·17	50·00	— 5·43	+ 10	S	—
245	South End Houts River Base (T.) ..	4658	23 51 27·45	14	1	—	0·87	0·19	30·62	— 3·17	+ 39	S	—
78	North End Belfast Base (T.)	6605	25 30 1·44	8	2	0·33	0·31	0·11	6·62	— 5·18	+ 53	M	§
76	Maré's Kop (T.)	6615	25 34 35·47	7	2	0·40	0·60	0·16	39·36	— 3·89	— 81	M	§
75	Langekloof (T.)	6342	25 37 1·95	9	2	0·27	0·34	0·12	6·75	— 4·80	— 33	M	§
94	North End Ottoshoop Base (T.)	4690	25 38 44·14	8	3	0·39	0·25	0·10	49·20	— 5·06	— 23	M	§
77	South End Belfast Base (T.)	6391	25 40 19·92	6	4	0·41	0·41	0·14	23·66	— 3·74	— 23	M	§
254	Meintjes Kop (T.)	4740	25 44 12·58	11	3	0·29	0·64	0·14	17·73	— 5·15	— 37	G	—
253	Muckleneuk (T.)	4722	25 45 50·27	11	3	0·36	0·58	0·14	55·65	— 5·38	+ 60	G	—
96	Observatory Hill, Johannesburg (T.) ..	5930	26 10 51·91	8	3	0·26	0·38	0·11	61·57	— 9·66	— 99	M	§
215	Driekuil (T.)	5054	26 45 28·49	12	3	0·34	0·86	0·20	32·30	— 3·81	+ 6	M	—
182	Gemsbokberg (O.R.C.)	6871	27 27 23·77	9	2	0·32	0·28	0·11	27·17	— 3·40	— 78	G	§
59	Inkwelo (N.)	6809	27 31 14·07	8	2	0·29	0·64	0·19	8·93	+ 5·14	— 29	G	§
180	Kaalkop II. (O.R.C.)	6384	27 35 4·84	10	1	—	0·30	0·13	5·87	— 1·03	+ 52	G	§
178	Vierfontein (O.R.C.)	5823	27 41 28·71	8	1	—	0·45	0·12	32·49	— 3·78	— 12	G	
106	Boschrand (O.R.C.)	4752	27 44 23·62	9	6	0·75	0·40	0·13	24·60	— 0·98	— 16	M	§

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station No.	Name of Station.	Height above M.S.L.	A Astronomical Latitude S.	No. of pairs observed.	No. of Nights.	p.e. of result from single pair ±	p.e. of a single declination ±	p.e. of resulting Latitude ±	G Seconds of Geodetic Latitude.	Difference A—G.	$\frac{\Sigma Z_n \backsim \Sigma Z_s}{\text{No. of pairs.}}$	Observer.	P.
		Eng. Ft.	° ′ ″			″	″	″	″	″	″		
181	Hermitage (O.R.C.)	7665	27 45 3·02	8	1	—	0·56	0·15	3·97	— 0·95	— 12	G	§
175	Zoetvlei (O.R.C.)	4317	27 50 29·29	9	2	0·27	0·53	0·15	28·39	+ 0·90	—112	G	—
107	Braunzijn Kop (O.R.C.)	4815	27 50 59·95	9	2	0·36	0·52	0·13	61·84	— 1·89	— 81	G	—
57	Salt Lake (N.)	4616	27 55 1·22	7	2	0·28	1·18	0·30	55·15	+ 6·07	+ 72	G	—
174	Therons Kop (O.R.C.)	5177	28 18 59·72	9	1	—	0·34	0·09	60·81	— 1·09	— 85	G	—
173	Schoongezicht (O.R.C.)	4654	28 19 22·75	9	1	—	0·65	0·21	25·29	— 2·54	— 91	G	—
134	Orange River (C.C.)	3893	29 39 52·92	12	2	0·28	0·59	0·15	53·40	— 0·48	+ 56	M	—
122	North End Wepener Base (O.R.C.) ..	4803	29 43 33·63	13	3	0·39	0·29	0·08	35·93	— 2·30	— 50	S	§
123	South End Wepener Base (O.R.C.) ..	5252	29 54 46·31	16	2	0·52	0·46	0·15	49·28	— 2·97	— 90	S	§
127	Aasvogelberg (O.R.C.)	7251	30 17 37·63	12	1	—	0·99	0·23	43·01	— 5·38	—165	S	§
129	Helvelyn (C.C.)	8156	30 42 8·55	12	2	0·33	0·49	0·14	10·23	— 1·68	— 2	S	§
130	Bendearg (C.C.)	9085	31 6 47·60	11	1	—	0·34	0·11	36·72	+10·88	+ 32	S	§
10	Xuka (C.C.)	6212	31 18 5·59	12	2	0·18	0·50	0·10	53·59	+12·00	+ 73	S	§
8	Lubisi (C.C.)	5823	31 46 41·54	12	1	—	0·29	0·08	30·74	+10·80	— 6	S	§
9	Owecweni (C.C.)	4198	31 52 28·43	13	1	—	0·28	0·08	23·13	+ 5·30	— 16	S	§

§ In Column P indicates Stations for which definite places for the stars have been obtained.

p.e. of a single declination of above ± 0″·40. p.e. Latitude ± 0″·13.

p.e. of a single declination of remainder ± 0″·62. p.e. Latitude ± 0·10.

Means of p.e. S.P. ± 0″·33.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—Lejuma. No. 248.

Latitude 23° 1′ S. Longitude 29° 26′ E. Observer—S. Date—1905, Aug. 14.

No. of Pair.	Stars.	Mean R. A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
					23° 1′		
		h. m. s.	° ′ ″	′ ″	″		
1	S 9002	16 30 24	35 43 18·93	−1 36·43	18·07	1	
	R 4312	31 55	10 22 30·07				N 1068
2	S 9048	34 57	45 10 52·38	+1 21·47	17·36	1	C 1989 A 6025
	R 4337	36 18	0 48 59·40				
3	S 9100	40 45	41 38 12·15	+1 48·27	17·32	1	C 2002
	R 4378	43 50	4 20 45·94				
4	S 9129	44 56	41 4 3·34	−0 26·31	18·83	1	C 2015 ⊙
	R 4383	47 28	4 59 26·94				
5	S 9184	48 49	43 9 40·62	+0 23·98	17·95	1	A 6109
	R 4406	52 40	2 52 7·32				
6	S 9282	58 10	25 33 44·50	+3 33·55	16·09	1	CGC 2880
	R 4436	16 59 8	20 21 40·58				CGC 2884
7	S 9311	17 1 38	40 53 54·71	+2 15·34	18·10	1	
	R 4459	3 46	5 4 10·81				
8	S 9368	8 19	26 52 15·94	−1 45·92	18·12	1	
	R 4491	10 58	19 13 52·14				
9	R 4508	13 26	10 7 6·04	+3 9·20	19·69	1	
	S 9450	16 15	35 49 14·94				
10	S 9517	21 48	−4 13 21·40	−0 39·48	17·91	1	C 2117 N 1111
	S 9525	23 39	50 17 16·18				A 6812
11	R 4559	25 30	0 59 1·32	+3 35·35	15·95	1	
	S 9560	27 13	44 56 19·88				A 6829
12	S 9570	28 30	32 30 58·62	−1 23·11	18·72	1	
	R 4574	29 45	13 34 25·04				
13	S 9589	30 56	38 0 25·38	−0 44·72	18·49	1	C 2137
	R 4589	32 41	8 3 41·04				⊙
14	S 9639	36 34	45 55 31·84	+0 43·42	19·01	1	A 6884
	R 4623	17 39 58	0 5 39·34				

Mean 23° 1′ 17″·97 ± 0″·19.

Station—Blaauwberg. No. 247.

Latitude 23° 4′ S. Longitude 28° 59′ E. Observer—S. Date—1905, Aug. 4.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers
					23° 3′		
		h. m. s.	° ′ ″	′ ″	″		
1	R 4026	15 31 34	15 11 56·93	+0 52·83	59·08	1	CGC 2120
	S 8511	34 22	30 54 15·57				C 1846
2	R 4064	39 35	−6 43 27·06	−1 48·81	60·39	1	N 997
	S 8581	15 42 54	52 55 5·46				

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Blaauwberg—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	23° 8′ ″		
3	R 4079	15 44 28	21 12 1·40	−3 19·52	59·57	1	CGC 2156
4	S 8581	47 54	25 2 36·77	−0 53·38	59·88		CGC 2164
	S 8628	48 57	24 57 44·93				
5	R 4115	50 59	1 58 7·00	−0 6·50	59·73	1	
	S 8668	51 48	44 15 5·45				A 5771
6	S 8684	53 50	38 7 30·82	−4 3·60	58·89	1	C 1899 (c)
	R 4185	55 40	8 8 34·16				
7	R 4147	15 58 59	9 39 27·84	−2 3·48	59·71	1	C 1911 (c)
8	S 8745	16 0 21	36 32 38·54	−0 41·19	58·51		
	S 8754	1 1	36 29 51·57				
9	R 4167	1 46	13 48 56·40	−2 22·87	59·25	1	CGC 2198
	S 8776	3 29	32 28 47·84				C 1916
10	S 8809	6 28	19 12 51·22	−1 27·10	57·73	1	C 1930 CGC 2211
	S 8835	9 30	26 57 58·44				CGC 2222
11	R 4221	11 55	3 48 6·33	−0 47·85	59·05	1	
	S 8860	12 41	42 26 27·47				C 1941 A 5888
12	R 4242	17 26	16 47 44·85	−4 20·99	60·29	1	CGC 2235
	S 8921	18 41	29 28 57·70				C 1956
13	S 8959	24 26	24 54 22·40	−1 5·80	59·62	1	CGC 2252
	R 4289	26 30	21 15 48·44				CGC 2259
14	S 9002	30 24	35 48 18·93	+1 5·64	60·14	1	
	R 4312	31 55	10 22 30·07				N 1063
15	R 4323	33 39	1 2 31·01	−2 41·99	59·71	1	
	S 9048	34 57	45 10 52·38				C 1989 A 6025
16	S 9060	36 5	17 38 31·18	−2 43·16	59·94	1	C 1992 CGC 2279
	S 9089	16 39 36	28 39 55·01				

Mean. 23° 8′ 59″·47 ± 0″·13.

Station—Loskop II. No. 243.

Latitude 23° 29′ S. Longitude 29° 20′ E. Observer—S. Date—1905, Sept. 2.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	23° 29′ ″		
1	R 4721	17 59 4	10 54 52·87	+0 51·79	7·43	1	CGC 2479
	S 9855	17 59 58	36 1 38·91				S 9907 CGC 2490
2	R 4734	18 1 59	23 6 57·48	+4 0·89	7·73	1	
	R 4748	5 55	23 48 16·25				
3	S 9988	9 0	43 11 50·66	+3 43·68	7·94	1	
	R 4773	10 58	3 38 57·86				
4	R 4792	14 40	15 52 15·36	+3 29·49	6·91	1	C 224
	S 9994	18 15 8	30 58 59·48				

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Loskop II—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	28° 29′ ″		
5	R 4802 S 10080	18 16 48 19 44	15 8 0·90 81 48 26·45	+0 53·71	7·39	1	
6	S 10088 R 4882	21 26 22 4	81 85 16·48 15 25 53·79	−1 28·19	6·92	1	
7	S 10075 R 4859	24 48 27 8	45 58 46·75 1 4 15·02	−2 28·44	7·45	1	A 6601
8	S 10106 R 4878	28 9 81 19	80 57 15·79 16 1 25·61	−0 14·51	6·19	1	OGC 2588
9	S 10145 S 10151	82 44 88 16	28 85 10·86 28 15 54·62	+8 88·90	6·64	1	OGC 2551
10	S 10180 R 4918	87 16 88 28	88 24 52·84 8 27 42·90	+2 47·71	5·58	1	⊙
11	R 4942 S 10224	41 84 42 26	1 8 44·12 45 55 3·17	−0 14·99	8·66	1	C 2299 A 6761
12	S 10258 R 4978	45 86 47 41	41 1 41·18 5 57 51·64	−0 89·86	6·52	1	
18	S 10285 R 4996	49 25 51 18	29 19 57·81 17 84 8·64	+2 6·87	7·09	1	
14	S 10818 R 5025	52 82 18 57 19	86 5 82·85 10 51 29·92	+0 86·16	7·55	1	

Mean. 28° 29′ 7″·14 ± 0″·14.

Station—North End Houts River Base. No. 246.

Latitude 23° 34′ S. Longitude 29° 20′ E. Observer—S.

Dates—1905, Sept. 11, 13.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	28° 34′ ″		
1	R 4861 S 10128	18 27 86 81 8	18 26 17·25 28 85 12·81	+3 17·57	2·60	2	OGC 2547
2	R 4888 S 10161	82 48 84 27	4 58 20·68 42 15 14·54	−0 18·48	4·10	2	A 6717
8	R 4928 S 10218	89 84 41 6	6 87 58·62 40 80 27·22	−0 8·99	8·98	2	A 6754
4	S 10255 R 4976	45 81 48 12	27 16 27·64 19 54 50·12	−1 84·80	4·08	2	
5	R 5011 S 10846	58 51 56 28	4 51 19·78 42 18 47·86	+1 29·49	8·31	2	⊙
6	S 10857 R 5042	18 58 19 19 0 15	31 11 11·24 15 48 14·05	+4 21·48	4·08	2	
7	S 10884 S 10404	1 18 19 8 16	5 1 81·20 42 2 87·27	+1 58·27	2·51	2	C 2844 N 1227 C 2847 A 6876

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

North End Houts River Base—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	23° 34′ ″		
8	S 10454 R 5102	19 10 21 11 36	25 49 54·75 21 14 25·64	+1 52·36	2·65	2	C 2361
9	S 10465 R 5129	13 28 15 35	35 35 39·88 11 28 41·07	+1 52·84	3·32	2	
10	S 10508 R 5162	18 46 20 42	50 1 33·52 −2 55 30·31	+1 0·76	2·36	2	S 10522
11	S 10544 R 5194	25 28 26 19	44 44 52·46 2 18 35·66	+2 20·00	4·06	2	A 7002
12	S 10581 R 5282	30 29 19 32 27	32 54 2·91 14 10 10·36	+1 56·73	3·37	2	

Mean 23° 34′ 3″ ·36 ± 0″·13.

Station—Schnells Kop. No. 241.

Latitude 23° 48′ S. Longitude 29° 57′ E. Observer—S.

Date—1905, October 13.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	23° 47′ ″		
1	S 11284 R 5747	21 11 43 13 58	31 8 33·97 16 34 43·71	−3 56·17	42·67	1	CGC 2953
2	R 5767 S 11337	17 37 18 22	6 2 16·74 41 24 50·86	+4 12·15	45·95	1	A 7645
3	S 11356 R 5795	20 27 23 48	38 14 21·46 9 24 14·92	−1 33·85	44·34	1	⊙
4	R 5803 S 11391	26 8 27 5	22 25 43·14 25 0 37·03	+4 35·63	45·71	1	
5	S 11417 S 11433	31 46 33 36	19 53 30·42 27 44 0·18	−1 0·12	45·18	1	CGC 2995 C 2708
6	R 5847 S 11479	36 28 40 46	14 28 17·60 33 9 6·64	−0 57·88	44·24	1	CGC 3007
7	R 5880 S 11514	44 3 46 29	5 50 39·12 41 51 27·36	−3 18·36	44·88	1	A 7805
8	R 5896 S 11529	47 56 48 37	11 0 28·34 36 30 32·03	+2 13·98	44·16	1	⊙
9	R 5901 S 11564	49 39 53 56	3 44 56·44 43 55 54·22	−2 41·14	44·19	1	A 7848
10	R 5928 S 11610	21 57 14 22 1 25	17 25 19·69 30 4 49·33	+2 41·04	45·55	1	
11	S 11633 R 5967	4 34 22 7 18	33 0 55·20 14 39 42·70	−2 33·20	45·75	1	CGC 3078

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Schnells Kop—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	28° 47′ ″		
12	S 11656	22 8 49	41 49 54·21	−8 4·17	43·86	1	A 7980
	R 5991	12 9	5 51 41·85				
13	R 5994	18 21	21 12 52·56	+1 42·82	48·68	1	
	S 11717	17 58	26 19 9·06				OGC 3108
14	S 11724	19 12	41 51 58·82	+1 55·09	48·85	1	
	R 6021	22 21 10	5 39 89·20				OGC 3114

Mean 28° 47′ 44″·57 ± 0″·17.

Station—South End Houts River Base. No. 245.

Latitude 23° 51′ S. Longitude 29° 14′ E. Observer—S.

Date—1905, June 26.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	28° 51′ ″		
1	S 7424	18 27 88	26 5 55·47	+2 22·97	27·98	1	
	R 8524	80 21	21 82 14·56				
2	S 7484	84 14	39 84 3·90	−2 17·70	27·05	1	O 1572 ◎
	S 7506	86 38	8 13 25·60				N 859 OGO 1855
3	R 8566	40 52	11 57 2·58	−0 21·47	27·02	1	OGO 1866
	S 7542	41 24	35 46 34·40				
4	S 7556	48 28	85 18 29·18	−1 89·95	25·48	1	
	R 8592	46 81	12 32 41·58				
5	S 7602	48 2	46 39 85·22	+0 35·70	27·70	1	A 5019
	R 8604	49 50	1 2 8·77				
6	S 7682	55 14	25 48 1·86	−1 82·70	25·85	1	
	R 8640	18 58 86	21 57 54·74				
7	S 7740	14 4 10	45 27 50·02	+0 44·77	28·89	1	A 5107
	R 8669	6 4	2 13 87·22				
8	S 7778	9 10	40 27 24·96	+1 4·29	27·94	1	A 5140
	R 8689	10 42	7 13 22·84				
9	S 7814	14 0	86 25 12·52	+0 27·25	28·12	1	
	R 8725	18 20	11 16 49·28				OGO 1956
10	S 7867	20 16	41 58 16·28	+4 8·57	27·25	1	O 1671
	R 8740	22 25	5 41 81·09				◎
11	R 8758	25 2	14 49 40·14	−0 16·01	29·86	1	OGO 1968
	S 7922	27 45	32 58 50·61				
12	S 7959	32 24	38 22 58·81	+1 9·65	27·27	1	O 1694
	R 8804	38 20	9 17 41·92				OGO 1995
13	S 8042	41 46	39 31 40·70	+2 21·78	27·57	1	
	R 8831	44 21	8 6 30·87				
14	R 8839	46 16	17 23 48·06	+4 2·21	27·88	1	OGO 2011
	S 8098	14 46 54	30 11 8·28				

Mean 28° 51′ 27″·45 ± 0″·19.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—North End Belfast Base. No. 78.

Latitude 25° 30′ S. Longitude 30° 4′ E. Observer—M.
Dates—1904, March 28, 29.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25° 30′ ″		
1	R 2049	7 57 48	6 4 10·51	−1 42·84	1·86	2	◎
	S 4130	8 3 36	44 59 18·88				◎ C 928
2	S 4268	14 58	36 21 41·77	+0 40·19	1·87	1	◎
	R 2164	21 28	14 37 1·59				◎
3	S 4506	33 46	25 55 7·87	+1 19·27	1·88	2	◎
	R 2252	41 40	25 2 17·36				◎ S 4612
4	S 4697	47 18	46 10 12·08	+1 10·67	1·10	2	◎
	R 2830	8 58 56	4 47 28·78				◎
5	S 4916	9 10 14	48 41 47·27	−2 24·50	0·91	2	◎
	R 2402	16 54	2 28 8·55				◎
6	S 5025	20 1	47 52 29·75	+1 55·80	1·09	1	◎
	R 2468	29 42	3 3 40·82				◎
7	S 5194	33 2	31 44 48·87	−0 56·74	0·98	2	◎
	R 2509	41 37	19 17 6·58				ⓒ
8	S 5334	47 1	46 29 7·49	−0 8·98	1·84	2	◎
	R 2550	9 50 48	4 31 14·15				◎

Mean 25° 30′ 1″·44 ± 0″·11.

Station—Maré's Kop. No. 76.

Latitude 25° 35′ S. Longitude 30° 11′ E. Observer—M.
Dates—1904, March 21, 22, 25.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25° 34′ ″		
1	S 4110	8 2 2	50 18 58·55	−1 12·48	35·87	2	◎
	R 2094	8 30	0 52 38·07				◎
2	S 4338	20 52	3 35 34·58	+0 32·60	35·49	2	N 586
	S 4437	28 8	47 32 31·24				◎
3	R 2257	43 20	6 12 16·88	−0 8·26	35·55	2	◎
	S 4687	46 28	44 57 1·80				◎
4	S 4734	50 36	47 9 19·02	−2 26·99	36·46	2	◎
	R 2820	8 56 44	4 4 47·87				◎
5	S 4981	9 15 49	33 41 49·85	−2 17·81	35·46	2	◎
	R 2421	21 28	17 31 57·20				ⓒ
6	R 2447	25 52	3 38 35·52	−0 35·59	34·57	2	ⓒ
	S 5136	27 51	47 31 44·82				ⓒ
7	R 2548	50 24	15 44 24·44	−0 33·77	31·91	2	◎
	S 5410	9 54 45	35 25 52·92				◎

Mean 25° 34′ 35″·47 ± 0″·16.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—Langekloof. No. 75.

Latitude 25° 37′ S. Longitude 29° 59′ E. Observer M.

Dates—1904, March 31, April 1.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25° 37′ ″		
1	S 4888 S 4406	8 20 52 26 3	8 85 34·59 47 36 29·57	+1 0·10	2·18	2	N 536 ◎ C 966
2	R 2215 S 4548	38 37 37 19	6 19 32·84 44 50 57·74	+1 46·23	1·52	2	◎ ◎
3	S 4570 R 2257	38 41 43 21	45 8 59·78 6 12 16·38	−1 4·85	3·18	2	◎ ◎
4	S 4784 R 2820	50 37 8 56 44	47 9 19·02 4 4 47·87	−0 1·87	1·57	2	◎ ◎
5	R 2871 S 4940	9 9 30 11 54	14 17 50·31 37 0 45·88	−2 16·75	1·84	2	◎ ◎
6	S 5018 S 5059	18 54 23 2	45 38 15·46 5 39 6·28	−1 38·81	2·06	2	◎ ◎ C 1094 R 2431
7	S 5367 R 2579	50 21 9 57 55	50 41 35·88 0 36 7·44	−1 49·80	1·88	2	◎ ◎ C 1172
8	S 5587 R 2666	10 11 30 15 18	42 37 58·58 8 34 29·87	+1 47·47	1·67	2	◎ ◎
9	S 5751 S 5775	26 10 10 28 26	7 8 41·73 44 7 24·75	−1 1·02	2·22	2	◎ ◎

Mean 25° 37′ 1″·95 ± 0″·12.

Station—North End Ottoshoop Base. No. 94.

Latitude 25° 39′ S. Longitude 25° 55′ E. Observer—M.

Dates—1904, June 12, 14, 19.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25° 38′ ″		
1	S 7580 R 3343	13 45 50 13 59 14	46 25 22·24 4 55 12·61	−1 32·66	44·77	2	◎ ◎
2	R 3664 S 7777	14 3 54 8 47	9 52 47·40 41 23 17·94	+0 40·83	43·50	3	◎ G 3616 ◎
3	S 7806 R 3740	18 15 22 22	45 36 54·62 5 41 14·73	−0 20·79	43·89	3	◎ C 1655 ◎
4	S 8085 S 8053	40 27 42 20	25 2 8·60 26 14 39·38	+0 20·77	44·76	3	◎ R 3810 ◎ C 1724
5	R 3881 S 8197	56 36 14 59 22	2 46 56·86 48 30 38·32	−0 1·09	44·00	3	◎ ◎
6	R 3912 S 8274	15 4 19 8 44	20 9 10·87 31 9 39·05	−0 40·64	44·32	3	◎ ◎
7	S 8347 R 3991	15 42 23 16	35 54 47·32 15 22 7·73	+0 16·29	43·81	3	◎ C 1795 ◎
8	S 8484 S 8516	31 12 15 34 36	27 19 2·22 28 30 22·45	−0 58·10	44·24	3	◎ C 1837 R 4024 ◎ C 1848 R 4043

Mean 25° 38′ 44″·13 ± 0″·10.

Table U—*continued*.

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—South End Belfast Base. No. 77.

Latitude 25° 40′ S. Longitude 30° 4′ E. Observer—M.
Dates—1904, February 2, 3, 4, 6, 7, 8.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25° 40′ ″		
1	S 1882	4 22 18	44 22 49·77	+0 42·27	19·02	3	⊙
	R 1085	4 29 14	6 56 23·73				⊙ G 1408
2	R 1240	5 8 37	16 19 7·71	+1 5·62	19·70	3	N 328
	S 2335	14 1	34 59 20·45				N 335
3	S 2372	19 7	14 1 1·99	+0 30·43	20·05	3	⊙ R 1289
	S 2441	24 57	37 18 37·26				⊙
4	S 2550	36 17	32 40 46·69	+1 55·26	20·52	4	⊙
	R 1404	39 10	18 36 8·83				⊙
5	S 2612	43 48	46 37 56·11	+2 23·58	19·86	3	⊙
	R 1456	5 50 46	4 37 56·45				⊙
6	S 2789	6 1 54	45 4 41·39	+0 37·70	20·11	4	⊙ C 709
	R 1546	6 10 10	6 14 43·43				⊙ C 728

Mean 25° 40′ 19″·92 ± 0″·14.

Station—Meintjes Kop. No. 254.

Latitude 25° 44′ S. Longitude 28° 13′ E. Observer—G.
Dates—1906, June 5, 6, 7.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25°44′ ″		
1	S 7019	12 36 15	45 37 53·11	+1 39·08	12·60	3	⊙
	R 3325	42 43	5 47 13·94				CGO 1731
2	R 3342	46 30	9 49 35·88	−4 1·16	12·38	3	CGO 1743
	S 7116	49 58	41 46 51·10				C 1467
3	R 3366	51 33	0 26 33·48	+0 52·93	11·53	2	
	S 7138	12 53 1	51 0 3·77				A 4681
4	S 7232	13 5 47	41 48 55·12	−3 54·20	11·79	3	C 1490 A 4763
	R 3448	9 51	9 52 16·86				
5	S 7280	11 41	31 0 31·41	+0 57·15	13·25	3	C 1510
	R 3475	18 53	20 26 0·80				
6	S 7367	21 41	48 53 35·22	+0 27·18	13·96	3	A 4859
	R 3504	26 2	2 38 58·44				OGO 1829
7	S 7484	34 17	39 34 20·82	−1 38·79	11.97	3	C 1572 ⊙
	R 3566	40 54	11 57 20·70				OGO 1866
8	S 7589	46 44	50 27 19·72	−0 41·05	12·11	3	A 5010
	R 3604	49 52	1 2 26·60				
9	R 3617	53 14	24 30 49·78	−0 28·48	13·30	3	
	S 7698	13 57 2	26 58 38·77				
10	S 7736	14 3 24	51 3 30·79	+0 23·78	12·74	3	⊙
	R 3680	8 50	0 24 7·14				
11	S 7866	20 8	44 57 16·59	+1 13·08	12·49	3	
	R 3751	14 23 44	6 28 42·33				

Mean 25° 44′ 12″·58 ± 0″·14.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—Muckleneuk. No. 253.

Latitude 25° 46′ S Longitude 28° 12′ E. Observer—G.
Dates—1906, June 9, 10, 11.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	25° 45′ ″		
1	S 7019 R 3325	12 36 15 42 43	45 37 53·11 5 47 13·94	+3 17·33	50·85	3	⊙ CGC 1731
2	R 3342 S 7116	46 30 49 58	9 49 35·88 41 46 51·10	−2 22·94	50·55	3	CGC 1748 C 1467
3	R 3366 S 7138	51 38 12 53 1	0 26 33·43 51 0 3·77	+2 30·94	49·54	3	A 4681
4	S 7232 R 3448	13 5 47 9 51	41 43 55·12 9 52 16·86	−2 16·52	49·47	3	C 1490 A 4763
5	S 7280 R 3475	11 41 18 53	31 0 31·41 20 26 0·80	+2 34·65	50·75	3	C 1510
6	S 7367 R 3504	21 41 26 2	48 53 35·22 2 33 58·44	+2 4·41	51·24	3	A 4859 CGC 1829
7	S 7484 R 3566	34 17 40 54	39 34 20·82 11 57 20·70	−0 1·55	49·21	3	C 1572 ⊙ CGC 1866
8	S 7589 R 3604	46 44 49 52	50 27 19·72 1 2 26·60	+0 56·54	49·70	2	A 5010
9	R 3617 S 7693	58 14 13 57 2	24 30 49·78 26 58 33·77	+1 9·17	50·95	3	
10	S 7736 R 3680	14 3 24 8 50	51 3 30·79 0 24 7·14	+2 1·10	50·06	3	⊙
11	S 7866 R 3751	20 8 14 28 44	44 57 16·59 6 28 42·33	+2 50·99	50·45	3	

Mean 25° 45′ 50″·27 ± 0″·14.

Station—Observatory Hill, Johannesburg. No. 96.

Latitude 26° 11′ S. Longitude 28° 5′ E. Observer—M.
Dates—1904, April 15, 28, 29.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	26° 10′ ″		
1	S 5462 S 5562	10 0 27 9 41	12 35 56·73 39 52 12·74	−3 12·34	52·39	3	N 640 ⊙
2	S 5629 R 2716	15 15 24 36	50 14 4·21 2 14 50·43	−3 35·27	52·05	3	⊙ N 667
3	S 5775 R 2753	28 27 32 18	44 7 24·75 8 20 26·36	−3 4·14	51·42	3	⊙ C 1229 ⊙
4	S 5986 S 6052	44 58 10 52 15	15 41 27·56 36 37 17·70	+1 29·63	52·26	3	N 690 N 696

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Observatory Hill, Johannesburg—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	″		
5	S 6095	10 56 56	1 58 4·10	−1 18·34	51·97	3	Ⓒ
	S 6155	11 2 11	50 26 16·52				Ⓒ
6	S 6224	8 34	49 12 49·74	+0 38·32	51·16	3	Ⓒ
	R 2917	11 47	3 7 35·95				N 716
7	R 2982	25 47	12 31 9·80	−1 56·97	51·55	2	Ⓒ
	S 6420	28 8	39 54 27·28				Ⓒ
8	S 6555	39 54	17 49 1·15	+0 24·40	52·32	3	N 738
	S 6628	11 48 36	34 31 54·70				Ⓒ

Mean 26° 10′ 51″·91 ± 0″·11.

Station—Driekuil. No. 215.

Latitude 26° 45′ S. Longitude 26° 2′ E. Observer—M.
Dates—1905, October 16, 17, 20.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	26°45′ ″		
1	R 5911	21 52 40	9 1 0·01	+2 10·61	29·10	3	CGC 3045
	S 11601	22 0 12	44 25 36·97				A 7885
2	R 5949	2 28	14 57 18·88	+1 25·91	29·07	3	
	S 11638	5 50	38 30 52·44				
3	R 5972	8 24	25 39 5·52	+0 4·12	28·10	3	
	S 11688	11 56	27 51 42·44				
4	S 11707	16 24	22 4 27·12	−2 7·00	27·54	3	O 2796
	S 11768	25 40	31 30 41·95				
5	S 11783	27 51	35 37 37·70	−1 52·22	28·00	3	
	R 6055	30 44	17 57 2·74				
6	S 11839	37 6	29 51 27·28	+1 55·79	30·32	3	
	S 11892	44 10	28 35 41·78				
7	S 11911	46 44	48 4 45·28	−1 48·21	27·45	3	
	R 6132	50 15	5 29 36·04				
8	S 11971	55 16	26 8 6·19	+1 40·26	28·98	3	
	S 11997	22 58 30	27 19 31·15				
9	S 12012	23 1 20	10 7 2·06	+0 40·51	26·90	3	
	S 12035	4 42	48 22 30·71				A 8246
10	S 12095	13 28	47 57 16·99	−2 28·39	27·81	3	
	R 6237	14 28	5 38 35·42				CGC 3253
11	S 12131	19 20	37 43 21·22	−0 51·96	28·68	3	
	R 6266	23 0	15 49 20·06				
12	R 6286	27 30	11 31 24·00	−0 14 75	29·99	3	CGC 3291
	S 12226	23 33 52	42 0 5·48				

Mean 26° 45′ 28″·49 ± 0″·20.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—Gemsbokberg. No. 182.

Latitude 27° 27′ S. Longitude 29° 26′ E. Observer—G.
Dates—1904, December 30; 1905, January 6.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 27′ ″		
1	S 1266	8 0 32	44 16 21·87 7·78	+0 82·40 +0 46·48	24·17	2	ⓞ
	R 741	1 56	10 37 21·74 7·69				ⓒ
2	S 1870	14 8	29 8 50·61	—4 57·89	28·62	1	ⓞ
	S 1401	18 12	25 55 52·42				ⓞ O 416
3	R 857	85 5	22 87 62·41 50·56	+1 1·46 +1 18·75	28·75	2	ⓞ
	S 1547	88 29	82 14 41·61 80·00				O 461
4	S 1598	48 86	24 10 19·10 7·85	—0 34·52 —0 23·02	24·57	2	O 479 N 242
	S 1698	8 56 54	80 45 88·84 28·08				ⓞ
5	R 977	4 4 11	8 55 27·98 18·22	—8 52·72 —8 48·86	24·12	2	ⓞ
	S 1767	5 88	46 6 66·05 56·44				ⓞ
6	S 1789	9 54	10 29 89·55 30·28	—2 22·65 —2 12·62	23·51	2	N 267
	S 1840	16 17	44 29 51·77 42·99				ⓞ
7	S 1860	19 9	25 6 55·76 47·22	—4 54·68 —4 48·46	28·68	2	ⓞ
	S 1959	29 48	29 57 87·71 30·02				ⓞ
8	R 1101	82 8	17 88 20·74 18·28	—1 44·90 —1 86·70	22·90	2	ⓞ
	S 2028	88 48	87 19 58·89 46·98				ⓞ
9	S 2081	44 8	30 11 83·66	+5 58·21	28·89	1	ⓒ
	S 2211	4 59 58	24 31 16·71				ⓒ

Mean 27° 27′ 28″·77 ± 0″·11.

Station—Inkwelo. No. 59.

Latitude 27° 31′ S. Longitude 29° 50′ E. Observer—G.
Dates—1904, December 10, 17.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 31′ ″		
1	S 620	1 29 59	16 10 5·65	—0 23·98	15·03	2	ⓞ R 869
	S 727	45 48	38 53 12·38				ⓒ
2	S 750	49 17	39 4 4·94	+6 8·61	14·15	2	ⓒ
	R 465	1 58 24	15 46 6·18				ⓒ S 812

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Inkwelo—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 31′ ″		
3	S 904 S 978	2 12 15 23 30	6 51 51·83 48 8 3·93	+1 15·66	13·54	2	R 580 C 292 N 142 C 319 N 154
4	S 1027 S 1106	30 1 38 48	8 16 42·72 46 55 50·79	−5 3·42	13·33	2	R 605 ⓒ
5	S 1037 S 1106	31 19 38 48	8 14 56·62 46 55 50·79	−4 10·03	13·67	2	ⓒ R 614 ⓒ
6	S 1156 S 1222	45 38 53 12	24 57 17·11 30 14 28·10	−4 38·76	13·84	2	ⓒ ⓒ
7	S 1255 S 1343	2 57 31 3 10 55	28 27 24·68 26 27 21·79	+3 47·51	[10·74]	1	C 387 CGC 445 ⓒ
8	S 1370 S 1401	14 2 3 18 11	29 8 50·61 25 55 52·42	−1 6·26	15·25	1	ⓒ ⓒ C 416

Result in brackets rejected. Mean 27° 31′ 14″·07 ± 0″·19.

Station—Kaalkop II. No. 180.

Latitude 27° 35′ S. Longitude 29° 8′ E. Observer—G.
Dates—1905, Jan. 16, 18.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 35′ ″		
1	S 1616 R 918	3 45 54 48 57	36 29 15·82 18 42 59·97	−1 4·06	3·83	1	C 488 ⓒ
2	R 937 S 1780	3 55 8 4 7 38	12 50 36·63 42 14 27·72	+2 33·72	5·90	1	ⓒ ⓒ
3	R 1040 S 1866	16 30 20 28	20 51 56·78 34 14 14·85	+1 59·49	5·30	1	C 538 C 544
4	S 1926 S 1955	26 31 29 37	46 43 23·31 8 25 47·73	+0 28·95	4·47	2	ⓒ ⓒ
5	R 1101 S 2028	32 5 38 42	17 38 13·23 37 19 46·93	+6 4·94	5·02	1	ⓒ ⓒ
6	S 2120 S 2190	48 0 4 57 18	35 3 55·14 20 11 23·83	−2 35·31	4·18	1	ⓒ ⓒ C 608
7	S 2218 S 2234	5 0 30 2 11	49 50 17·86 5 12 31·92	+3·39·56	4·45	1	ⓒ C 611
8	R 1224 S 2357	4 1 17 2	4 34 45·85 50 42 28·98	−3 32·34	5·07	1	ⓒ S 2242 C 635
9	S 2372 S 2431	19 9 24 2	14 0 58·43 41 1 31·21	+3 50·64	5·46	1	ⓒ C 645
10	S 2550 S 2582	36 19 5 40 31	32 40 44·62 22 28 44·84	+0 20·00	4·73	1	ⓒ C 675

Mean 27° 35′ 4″·84 ± 0″·13.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—Vierfontein. No. 178.

Latitude 27° 41′ S. Longitude 28° 35′ E. Observer—G.
Date—1905, Feb. 1.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 41′ ″		
1	S 1981 S 2008	4 31 52 36 10	30 45 23·48 24 40 4·54	−1 14·70	29·32	1	O 555 O 565
2	S 2049 R 1149	40 41 4 46 42	28 7 28·00 27 15 47·98	−0 8·71	29·28	1	ⓞ S 2107
3	R 1218 S 2251	5 3 1 4 52	19 31 29·05 35 50 26·21	+0 31·01	28·64	1	ⓞ ⓞ
4	S 2304 R 1298	11 7 20 52	36 5 8·13 19 27 33·28	−4 52·50	28·20	1	ⓞ ⓞ
5	S 2441 S 2466	24 59 28 32	37 18 34·16 17 53 23·78	+5 29·32	29·18	1	ⓞ O 654
6	S 2597 S 2632	42 28 45 55	32 20 32·06 23 0 1·15	+1 11·29	27·89	1	ⓞ ⓞ
7	R 1448 S 2671	48 0 49 19	17 34 42·83 37 39 4 10	+4 35·03	28·50	1	ⓞ ⓞ
8	S 2699 R 1482	51 51 5 57 28	50 23 37·07 5 8 14·23	−4 26·96	28·69	1	ⓞ ⓞ

Mean 27° 41′ 28″·71 ± 0″·12.

Station—Boschrand. No. 106.

Latitude 27° 44′ S. Longitude 27° 11′ E. Observer—M.
Dates—1905, Aug. 22, 23, 24, 25, 27, Sept. 4.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h m. s.	° ′ ″	′ ″	27° 44′ ″		
1	R 4585 S 9675	17 32 8 41 0	15 20 20·47 40 5 26·09	+1 31·20	24·48	6	N 1125 OGC 2399 N 1135
2	S 9802 S 9863	17 53 48 18 1 30	9 45 44·33 45 46 40·22	−1 48·71	23·57	6	N 1148 ⓞ
3	R 4759 S 10015	8 6 17 54	21 5 2·68 34 25 47·24	−1 0·71	24·25	6	N 1166 OGC 2492 N 1175
4	S 10052 R 4875	22 48 30 2	47 16 51·54 8 18 39·05	−3 21·47	23·83	6	ⓞ N 1189 OGC 2545
5	S 10189 R 4981	38 24 49 18	39 46 54·09 15 43 18·69	−0 43·08	23·31	6	ⓞ ⓞ
6	S 10367 S 10384	18 59 36 19 1 12	50 27 59·40 5 1 31·02	+0 38·09	23·30	6	A 6856 N 1227
7	R 5094 S 10521	9 42 20 56	25 25 14·95 29 55 58·52	+3 50·65	23·18	6	N 1237 ⓞ
8	S 10568 R 5228	28 12 31 48	48 18 15·23 7 14 20·25	−1 55·10	22·64	6	C 2408 A 7015 N 1266
9	S 10660 R 5338	43 12 19 58 8	29 1 23·11 26 27 10·26	+0 7·32	24·01	6	ⓞ G 5101 S 10731 G 5173 OGC 2758

Ground at this point very unsteady.

Mean 27° 44′ 23″·62 ± 0″·13.

Table U—*continued.*

Results of Latitude Observations—*continued.*

Station—Hermitage. No. 181.

Latitude 27° 45′ S. Longitude 29° 21′ E. Observer—G.
Date—1905, Jan. 10.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 45′ ″		
1	S 1490 S 1557	3 31 58 39 19	17 46 53·03 37 36 47·70	+3 12·30	2·66	1	Ⓒ C 465
2	S 1611 R 901	45 5 47 14	37 54 43·47 17 27 1·07	+4 9·72	1·99	1	Ⓒ C 484 Ⓒ
3	S 1649 S 1698	49 40 3 56 53	24 53 35·38 30 45 28·08	−4 27·84	3·89	1	Ⓒ C 494 Ⓒ
4	R 995 S 1875	4 7 26 21 25	20 36 10·18 34 58 18·74	−2 11·59	2·87	1	Ⓒ Ⓒ
5	S 1930 S 2009	27 13 36 17	35 51 33·20 19 51 12·76	−6 20·39	2·59	1	Ⓒ Ⓒ
6	S 2047 S 2134	40 45 4 49 9	3 25 43·48 51 53 3·53	+5 39·65	3·16	1	C 574 Ⓒ
7	S 2220 S 2322	5 0 52 13 18	41 52 50·84 13 37 14·37	+0 0·72	3·32	1	Ⓒ Ⓒ
8	S 2357 R 1814	17 2 5 23 52	50 42 28·98 4 46 29·10	+0 34·64	3·68	1	C 635 Ⓒ

Mean 27° 45′ 3″·02 ± 0″·15.

Station—Zoetvlei. No. 175.

Latitude 27° 50′ S. Longitude 26° 22′ E. Observer—G.
Dates—1905, April 3, 4.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 50′ ″		
1	S 4097 S 4143	8 0 15 5 8	39 44 7·03 15 58 12·71	−0 40·03	29·84	1	Ⓒ
2	S 4319 S 4468	19 36 30 50	48 11 6·67 7 39 19·05	−4 43·09	29·77	2	Ⓒ A 2947
3	S 4517 S 4613	34 18 41 53	42 39 23·87 13 12 0·80	−5 13·85	28·49	1	C 985 Ⓒ C 1004
4	S 4678 S 4765	46 7 54 16	39 57 57·96 15 46 19·18	−1 35·79	[32·78]	2	Ⓒ
5	S 4787 R 2343	8 56 33 9 4 0	40 53 2·33 14 45 19·56	+1 18·91	29·85	2	Ⓒ Ⓒ
6	S 4938 R 2408	11 52 18 4	38 10 25·28 17 29 15·50	+0 38·02	28·41	2	Ⓒ
7	S 5130 R 2476	27 28 32 17	31 27 10·38 24 16 44·46	−1 27·50	29·92	2	
8	S 5224 S 5285	35 42 42 30	10 20 18·28 45 28 43·72	−4 1·89	29·11	2	
9	S 5336 S 5407	47 48 9 53 4	7 39 26·59 47 57 38·69	+1 56·14	28·78	2	C 2166

Result in brackets rejected. Mean 27° 50′ 29″·29 ± 0″·15.

Table U—*continued.*

Results of Latitude Observations—*continued.*

Station—Braunzijn Kop. No. 107.
Latitude 27° 51′ S. Longitude 26° 56′ E. Observer—G.
Dates—1905, March 24, 25.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 50′ ″		
1	S 4097 S 4143	8 0 15 5 8	39 44 7·03 15 58 12·71	−0 9·50	60·37	2	Ⓒ
2	S 4319 S 4468	19 36 30 50	48 11 6·67 7 39 19·05	−4 12·35	60·51	2	Ⓒ A 2947
3	S 4517 S 4613	34 18 41 53	42 39 23·37 13 12 0·30	−4 42·67	59·67	2	C 985 Ⓒ C 1004
4	S 4678 S 4765	46 7 54 16	39 57 57·96 15 46 19·18	−1 5·30	[62·76]	2	Ⓒ
5	S 4787 R 2343	8 56 33 9 4 0	40 58 2·33 14 45 19·56	+1 49·38	60·31	2	Ⓒ Ⓒ
6	S 4933 R 2408	11 52 18 4	38 10 25·28 17 29 15·50	+1 8·55	58·94	2	Ⓒ
7	S 5130 R 2476	27 28 32 17	31 27 10·33 24 16 44·46	−0 56·99	60·43	2	
8	S 5224 S 5285	35 42 42 30	10 20 18·28 45 28 43·72	−3 31·38	59·62	2	
9	S 5336 S 5407	47 48 9 58 4	7 39 26·59 47 57 33·69	+2 27·08	59·72	2	C 2166

Result in brackets rejected. Mean 27° 50′ 59″·95 ± 0″·13.

Station—Salt Lake. No. 57.
Latitude 27° 55′ S. Longitude 30° 4′ E. Observer—G.
Dates—1904, Nov. 27, 29.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	27° 54′ ″		
1	S 331 R 194	0 45 34 51 13	43 55 6·45 11 47 11·21	+3 52·48	61·31	2	S 364
2	R 223 S 419	0 56 43 1 0 7	7 18 58.54 48 27 21·00	+1 51·12	60·89	1	C 137
3	S 430 S 472	1 48 9 34	47 13 58·33 8 26 19·54	+4 52·46	61·64	2	C 143 N 66 A 347
4	R 333 S 606	22 41 27 34	9 47 39·23 46 4 11·93	+0 3·80	59·38	2	A 487
5	S 632 R 390	31 42 34 20	30 23 57·61 25 30 37·22	−2 15·78	61·64	2	S 651 C 214
6	S 754 R 459	49 48 55 41	46 46 22·63 8 59 18·57	+2 12·97	63·57	1	C 241 N 122 A 607
7	S 806 R 476	1 57 51 2 1 27	45 10 30·01 10 44 2·43	−2 15·19	61·03	1	A 652

Mean 27° 55′ 1″·22 ± 0″·30.

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Station—Therons Kop. No. 174.

Latitude 28° 19′ S. Longitude 26° 47′ E. Observer—G.
Date—1905, April 11.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	28° 18′ ″		
1	S 4101 S 4127	8 0 34 3 30	32 24 21·10 24 1 48·57	+5 54·81	59·15	1	C 927 ⓒ
2	S 4160 S 4298	6 28 18 19	43 50 33·00 12 44 56·01	+1 15·35	59·85	1	ⓒ C 952
3	S 4353 R 2192	22 32 28 8	41 50 31·76 14 42 29·66	+2 29·37	60·08	1	ⓒ ⓒ
4	S 4473 R 2218	30 54 34 23	37 17 4·13 19 24 11·02	−1 37·98	59·59	1	C 978 ⓒ
5	S 4632 R 2287	42 48 50 43	45 41 38·23 11 0 30·83	−2 4·59	59·94	1	C 1009 ⓒ
6	S 4765 S 4787	54 16 8 56 33	15 46 9·19 40 53 2·33	−0 36·86	58·90	1	ⓒ
7	S 4939 S 4971	9 11 48 15 12	45 9 35·47 11 34 25·27	−3 0·32	60·05	1	C 1060, A 3296 C 1071
8	S 5055 S 5161	22 55 30 20	8 14 47·41 48 34 58·94	−5 53·19	59·99	1	N A ⓒ
9	S 5224 S 5334	35 42 9 47 3	10 20 18·28 46 29 24·26	−5 51·33	59·94	4	ⓒ

Mean 28° 18′ 59″·72 ± 0″·09.

Station—Schoongezicht. No. 173.

Latitude 28° 19′ S. Longitude 26° 24′ E. Observer—G.
Date—1905, April 16.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	28° 19′ ″		
1	S 4353 R 2192	8 22 32 28 8	41 50 31·76 14 42 29·66	+2 51·64	22·35	1	ⓒ ⓒ
2	S 4473 R 2218	30 54 34 23	37 17 4·13 19 24 11·02	−1 14·67	22·90	1	C 978 ⓒ
3	S 4632 R 2287	42 48 50 43	45 41 38·23 11 0 30·83	−1 41·64	22·89	1	C 1009 ⓒ
4	S 4765 S 4787	54 16 8 56 33	15 46 9·19 40 53 2·33	−0 14·41	21·35	1	ⓒ
5	S 4939 S 4971	9 11 48 15 12	45 9 35·47 11 34 25·27	−2 38·47	21·90	1	C 1060, A 3296 C 1071
6	S 5055 S 5161	22 55 30 20	8 14 47·41 48 34 58·94	−5 29·34	23·84	1	N A ⓒ
7	S 5224 S 5334	35 42 47 3	10 20 18·28 46 29 24·26	−5 27·36	23·91	1	ⓒ
8	S 5342 R 2549	48 0 9 50 35	46 6 7·37 10 35 4·80	−1 13·20	22·89	1	C 1159, A 3533

Mean 28° 19′ 22″·75 ± 0″·21.

Table U—*continued.*

Results of Latitude Observations—*continued.*

Station—Orange River. No. 134.

Latitude 29° 40′ S. Longitude 24° 16′ E. Observer—M.
Dates—1905, Sept. 22, 25.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	29° 39′ ″		
1	S 10592	19 32 53	58 29 8·92	+0 3·45	53·13	2	◎
	R 5259	35 50	0 50 30·45				◎
2	R 5268	38 8	15 41 26·80	+1 53·85	51·95	2	CGC 2721
	S 10640	40 46	43 34 29·40				A 7087
3	S 10741	54 6	45 22 20·84	+1 41·60	53·21	2	A 7163
	R 5359	19 56 40	13 54 2·38				CGC 2766
4	R 5410	20 6 0	9 7 26·08	−3 71·79	53·02	2	◎
	S 10871	14 4	50 18 55·53				◎
5	S 10906	19 28	41 6 8·38	+2 53·40	53·08	2	◎
	S 10934	23 27	18 7 40·98				N 1829
6	R 5538	31 2	12 42 37·11	+1 13·48	53·85	2	CGC 2846
	S 11067	42 57	46 34 43·78				A 7452
7	S 11134	51 24	44 28 6·66	+0 18·30	52·22	2	A 7500
	R 5645	53 26	14 51 1·18				CGC 2898
8	S 11171	56 54	39 0 9·53	+2 52·99	53·66	2	N 1876
	S 11187	20 59 0	20 18 51·81				N 1877
9	R 5688	21 2 6	19 28 6·40	+1 28·45	51·54	2	CGC 2919
	S 11249	6 58	39 48 39·78				
10	S 11305	13 54	45 25 22·75	+0 4·31	53·33	2	A 7619
	R 5753	14 57	13 54 15·29				◎
11	R 5789	22 12	14 0 0·11	+1 50·00	53·80	2	◎
	S 11390	27 15	45 16 7·48				C 2693 ◎ A 7697
12	S 11527	48 10	37 48 42·98	−2 9·70	52·22	2	N 1484
	R 5904	21 50 21	21 35 20·86				◎

Mean 29° 39′ 52″·92 ± 0″·15.

Station—North End Wepener Base. No. 122.

Latitude 29° 43′ S. Longitude 26° 59′ E. Observer—S.
Dates—1905, March 2, 3, 4, 5.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	29° 43′ ″		
1	S 2749	5 58 7	27 21 26·81	−2 15·52	33·53	4	◎
	S 2772	6 0 48	32 10 11·30				◎
2	S 2826	5 54	31 0 22·91	+0 12·57	33·63	4	◎
	S 2861	9 16	28 26 19·21				◎
3	S 2911	15 0	59 10 8·61	+1 55·12	33·30	3	◎
	S 2989	6 22 24	0 13 7·76				◎

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

North End Wepener Base—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	29° 48′ ″		
4	S 3032	6 27 1	27 42 12·09	−1 46·74	33·39	4	◎
	S 3100	32 54	31 48 28·16				◎
5	S 3166	38 59	59 1 56·25	−0 9·99	33·60	3	◎
	R 1699	45 58	0 25 30·94				◎
6	S 3279	50 12	24 3 54·22	+0 10·91	33·30	3	◎
	S 3317	53 55	35 22 50·56				◎
7	S 3348	6 55 56	45 38 10·82	−0 16·12	32·56	2	
	R 1768	7 0 40	13 49 26·58				◎
8	S 3426	2 57	42 10 58·32	+2 54·20	33·68	2	◎
	R 1801	7 11	17 10 25·64				◎
9	S 3491	9 11	36 4 25·85	+1 37·34	34·25	3	◎
	S 3502	10 42	23 19 27·97				◎
10	R 1841	15 28	3 44 18·78	−2 25·18	33·74	3	◎
	S 3594	17 27	55 47 38·97				◎
11	S 3645	22 4	31 32 58·47	+0 10·79	34·45	3	C 851
	S 3685	26 57	27 53 48·84				◎
12	S 3719	30 18	23 15 59·02	−2 49·31	33·65	3	◎
	S 3780	35 18	36 16 46·90				◎
13	S 3828	39 42	28 11 5·85	−3 23·51	33·90	3	◎
	S 3918	7 44 59	31 22 49·47				◎

Mean 29° 48′ 33″·63 ± 0″·08.

Station—South End Wepener Base. No. 123.

Latitude 29° 55′ S. Longitude 27° 3′ E. Observer—S.

Dates—1905, March 17, 18.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	29° 54′ ″		
1	R 1622	6 27 16	8 5 23·82	−0 40·24	47·71	2	◎
	S 3061	29 5	51 45 32·59				◎
2	S 3108	33 48	18 9 17·76	−1 30·82	45·17	2	◎
	S 3169	39 34	41 43 14·28				◎
3	S 3193	42 31	14 19 25.62	+1 21·17	46·41	2	◎
	S 3240	46 46	45 27 24·86				◎
4	S 3257	48 22	36 6 50·97	−2 55·58	45·98	2	◎ C 780
	S 3281	50 16	23 48 32·15				◎
5	S 3326	54 46	26 35 4·87	−3 5·55	45·87	1	◎
	S 3349	56 11	33 20 37·97				◎
6	R 1760	58 34	16 38 39·29	−0 1·27	46·18	1	◎
	S 3386	6 59 19	43 15 55·62				
7	S 3423	7 2 7	38 14 11·64	−1 42·38	46·07	1	◎ C 810
	R 1802	7 17	21 38 45·25				◎

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

South End Wepener Base—*continued.*

No. of Pair.	Stars.	Mean.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	29° 54′ ″		
8	S 3495	7 9 57	43 43 23·35	—3 24·89	46·51	2	Ⓒ
	R 1840	15 10	16 12 59·46				Ⓒ
9	R 1844	16 33	8 41 44·20	—2 51·77	45·46	2	Ⓒ
	S 3607	18 27	51 13 30·25				
10	S 3633	21 5	31 37 19·06	+0 46·52	46·12	1	Ⓒ C 848
	S 3661	24 1	28 10 40·15				Ⓒ
11	S 3690	27 1	33 53 26·93	+0 47·60	46·02	1	Ⓒ
	S 3728	30 34	25 54 29·91				Ⓒ
12	S 3744	32 15	33 10 53·76	+1 15·71	45·46	1	Ⓒ
	S 3751	33 15	26 36 5·73				Ⓒ
13	S 3829	39 48	35 49 26·11	—0 43·08	44·22	1	Ⓒ
	S 3860	41 51	24 1 28·50				Ⓒ
14	S 3885	43 17	39 49 33·63	+ 1 1·57	45·12	1	Ⓒ
	R 1995	45 35	19 57 53·46				Ⓒ
15	R 2002	46 59	24 17 8·40	—2 38·34	46·52	1	Ⓒ S 3940
	S 3980	50 40	35 37 41·32				Ⓒ
16	S 4011	53 51	43 14 43·64	—3 20·99	47·51	1	Ⓒ
	R 2037	7 55 52	16 41 33·37				Ⓒ

Mean 29° 54′ 46″·07 ± 0″·15.

Station—Aasvogelberg. No. 127.

Latitude 30° 18′ S. Longitude 27° 3′ E. Observer—S.
Date—1905, March 26.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	30° 17′ ″		
1	S 3882	7 40 1	44 55 54·82	—3 1·59	36·20	1	Ⓒ
	R 1980	43 19	15 45 20·76				Ⓒ
2	S 3934	46 21	46 8 2·08	—4 26·75	37·43	1	C 900
	S 3952	47 56	14 36 6·28				Ⓒ
3	S 4018	55 0	3 25 13·42	—1 38·08	37·13	1	Ⓒ
	S 4035	55 44	57 13 17·01				Ⓒ
4	S 4094	7 59 59	49 41 3·90	—4 44·92	38·39	1	Ⓒ
	R 2077	8 4 26	11 3 42·72				Ⓒ
5	S 4206	9 0	46 21 33·96	—1 14·98	37·24	1	Ⓒ
	R 2121	14 12	14 16 10·47				Ⓒ
6	S 4282	16 10	47 53 57·19	—1 50·03	35·72	1	Ⓒ
	S 4298	18 9	12 44 54·31				
7	S 4319	19 36	48 11 6·67	—1 36·42	37·90	1	Ⓒ
	R 2154	20 31	12 27 21·98				Ⓒ
8	R 2160	21 8	21 49 53·43	+1 15·94	39·89	1	Ⓒ
	S 4356	8 22 48	38 44 54·47				Ⓒ

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Aasvogelberg—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	30° 17′ ″		
9	S 4413	8 26 40	46 0 47·77	−4 0·66	38·06	1	ⓒ
	R 2192	28 8	14 42 29·66				ⓒ
10	S 4496	33 2	50 38 23·05	−4 49·10	38·25	1	ⓒ
	R 2226	36 16	10 6 31·66				ⓒ
11	S 4573	39 15	35 36 6·79	−1 39·98	38·82	1	ⓒ
	S 4612	41 43	25 2 30·80				
12	S 4644	48 13	55·30 33·95	+0 5·38	36·49	1	ⓒ
	R 2281	8 49 38	5 4 28·28				ⓒ

Mean 30° 17′ 37″·68 ± 0″·23.

Station—Helvelyn. No. 129.

Latitude 30° 42′ S. Longitude 27° 16′ E. Observer—S.
Dates—1905, April 14, 15.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	30° 42′ ″		
1	R 2193	8 28 11	14 5 43·12	+0 51·98	9·74	2	ⓒ
	S 4457	29 51	47 16 52·40				ⓒ
2	R 2210	33 4	12 15 17·08	+1 42·77	8·72	2	ⓒ
	S 4518	34 12	49 5 34·82				ⓒ
3	R 2227	36 25	8 42 51·74	−0 49·58	8·25	2	ⓒ
	S 4549	37 15	52 43 3·98				ⓒ
4	S 4605	40 54	53 10 48·44	−0 47·07	8·38	2	ⓒ
	R 2265	45 3	8 17 2·46				ⓒ
5	S 4688	46 54	6 49 16·06	−0 29·63	7·51	1	ⓒ
	S 4750	52 30	54 35 58·22				ⓒ
6	R 2313	55 40	22 19 19·15	+1 37·62	8·20	2	ⓒ
	S 4810	8 58 28	39 1 42·01				ⓒ
7	S 4880	9 0 53	46 43 10·28	−2 6·07	8·88	2	O 1038
	R 2343	4 0	14 45 19·62				ⓒ
8	S 4881	6 35	47 5 20·86	+0 25·02	7·98	2	ⓒ
	R 2371	9 33	14 18 5·06				ⓒ
9	R 2383	12 21	10 42 14·82	+1 28·62	7·86	2	ⓒ
	S 4973	14 56	50 39 3·67				ⓒ
10	S 5011	18 53	39 22 13·28	+3 13·52	8·68	1	ⓒ
	R 2430	22 57	21 55 37·03				ⓒ
11	S 5095	25 42	26 10 22·88	−1 46·71	8·88	2	ⓒ O 1100
	S 5132	27 35	35 17 28·31				ⓒ
12	S 5177	31 57	30 48 26·73	+1 38·44	9·49	2	ⓒ
	S 5197	9 33 10	30 32 35·37				ⓒ

Mean 30° 42′ 8″·55 ± 0″·14.

Table U—*continued.*

Results of Latitude Observations—*continued.*

Station—Bendearg. No. 130.

Latitude 31° 7′ S. Longitude 27° 59′ E. Observer—S.
Date—1905, April 30.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	31° 6′ ″		
1	S 5825 S 5833	10 32 46 33 28	26 55 12·30 35 13 35·14	+2 23·74	47·50	1	ⓒ ⓒ
2	S 5872 R 2777	35 58 37 50	48 47 5·45 13 28 39·21	−1 4·38	47·95	1	ⓒ ⓒ
3	S 5927 R 2813	40 13 46 16	59 37 8·84 2 35 19·55	+0 33·48	47·67	1	ⓒ ⓒ
4	S 6021 S 6045	48 50 51 9	19 37 37·95 42 30 50·48	+2 33·70	47·92	1	ⓒ ⓒ
5	S 6063 R 2848	53 56 10 55 11	59 13 25·56 2 57 46·00	+1 11·52	47·30	1	ⓒ C 1275 ⓒ
6	R 2880 S 6207	11 1 56 7 6	12 29 15·09 49 39 11·48	+2 33·70	46·98	1	ⓒ ⓒ
7	S 6236 R 2917	9 24 11 50	59 6 7·38 3 7 55·47	−0 14·39	47·04	1	ⓒ
8	S 6281 S 6301	13 4 14 47	34 13 5·71 27 57 19·95	+1 35·24	48·07	1	ⓒ ⓒ
9	S 6345 R 2957	19 49 21 18	42 8 50·35 20 3 33·40	+0 36·68	48·80	1	ⓒ ⓒ
10	R 2974 S 6402	24 24 26 23	3 55 32·98 58 17 14·77	+0 23·31	47·16	1	ⓒ ⓒ
11	S 6447 R 3013	30 51 11 33 33	60 22 6·91 1 54 36·90	−1 34·08	47·22	1	ⓒ ⓒ

Mean 31° 6′ 47″·60 ± 0″·11.

Station—Xuka. No. 10.

Latitude 31° 18′ S. Longitude 28° 0′ E. Observer—S.
Dates—1905, May 7, 10.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	31° 18″ ″		
1	S 5990 R 2816	10 45 10 47 0	41 51 56·47 20 44 46·23	−0 15·30	5·55	1	ⓒ ⓒ
2	R 2825 S 6051	48 50 52 0	14 56 20·78 47 35 1·61	+2 24·87	6·07	1	ⓒ ⓒ
3	S 6073 R 2858	55 0 10 57 45	53 1 50·48 9 29 1·79	+2 39·62	5·75	1	ⓒ ⓒ
4	R 2878 S 6207	11 1 45 7 6	12 54 12·75 49 39 11·48	+1 24·10	6·22	2	ⓒ ⓒ

Table U—*continued.*

RESULTS OF LATITUDE OBSERVATIONS—*continued.*

Xuka—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	31° 18′ ″		
5	S 6236 R 2916	11 9 24 11 46	59 6 7·38 3 26 53·38	+1 35·33	5·71	2	◎ ◎
6	S 6296 S 6298	13 56 14 36	48 16 6·61 14 15 51·55	+2 6·47	5·55	2	◎ C 1311 N 719
7	S 6319 R 2952	16 38 20 3	45 21 56·89 17 9 43·54	+2 15·29	5·51	2	◎ S 6347 C 1320
8	S 6375 R 2979	23 53 25 13	45 15 4·84 17 21 41·69	−0 19·06	4·20	1	◎ ◎
9	S 6427 R 3006	28 36 31 51	53 47 58·63 8 47 13·89	+0 28·31	5·07	2	◎ ◎
10	S 6491 R 3037	33 59 37 11	38 48 17·27 23 51 29·86	+0 42·49	6·05	2	◎ ◎ S 6531
11	S 6576 R 3063	42 3 43 40	39 58 59·46 22 33 46·74	+1 41·90	5·01	2	◎ ◎
12	S 6628 S 6647	48 39 11 50 50	34 32 14·72 27 56 51·75	+3 32·70	6·03	2	◎ ◎

Mean 31° 18′ 5″·59 ± 0″·10.

Station—Lubisi. No. 8.

Latitude 31° 47′ S. Longitude 27° 30′ E. Observer—S.
Date—1905, June 6.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	31° 46″ ″		
1	S 6617 S 6626	11 46 53 48 7	30 17 55·68 33 22 46·30	−3 39·68	41·29	1	◎ ◎
2	S 6646 S 6648	50 41 51 5	24 19 48·55 39 9 36·30	+1 59·20	41·62	1	◎ ◎
3	S 6677 S 6698	54 31 56 56	29 31 54·19 34 7 17·88	−2 55·18	40·86	1	◎ ◎
4	S 6709 S 6746	11 58 10 12 1 12	31 9 44·04 32 25 38·00	−0 58·97	42·05	1	◎ ◎
5	S 6767 R 3158	3 27 6 30	60 19 5·19 3 14 55·01	−0 19·13	40·97	1	◎ ◎
6	S 6823 R 3181	10 3 10 51	40 36 32·84 22 49 29·14	+3 40·84	41·33	1	◎ ◎
7	S 6835 R 3192	12 34 13 28	48 28 45·86 15 3 58·54	+2 49·75	41·95	1	A 4441 ◎
8	R 3227 S 6933	21 54 12 24 28	5 3 57·25 58 29 52·91	−0 13·14	41·94	1	◎ ◎

Table U—*concluded.*

RESULTS OF LATITUDE OBSERVATIONS—*concluded.*

Lubisi—*continued.*

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	3° 46′ ″		
9	R 3271 S 7015	12 31 0 35 58	20 0 10·46 43 34 46·47	−0 46·37	42·09	1	⊙ ⊙
10	S 7047 R 3320	39 29 41 36	52 14 7·69 11 17 40·15	+0 47·38	41·30	1	⊙ ⊙
11	S 7085 R 3352	45 40 48 44	59 48 44·68 3 42 25·64	+1 6·01	41·17	1	⊙ ⊙
12	S 7141 S 7176	53 27 12 57 14	35 45 41·87 27 46 31·65	+0 34·66	41·42	1	⊙ ⊙

Mean 31° 46′ 41″·54 ± 0″·08.

Station—Cwecweni. No. 9.

Latitude 31° 52′ S. Longitude 28° 2′ E. Observer—S.
Date—1905, May 16.

No. of Pair.	Stars.	Mean R.A.	Mean Declination.	Sum of Corrections.	Latitude.	No. of Nights.	Other Catalogue Numbers.
		h. m. s.	° ′ ″	′ ″	31° 52′ ″		
1	R 2934 S 6321	11 15 44 16 40	9 46 29·01 53 58 13·85	+0 7·11	28·54	1	⊙ O 1315
2	S 6340 S 6352	19 12 20 57	26 26 13·94 37 13 29·71	+2 36·20	28·02	1	⊙ ⊙
3	S 6378 R 2983	24 12 26 1	57 37 7·30 6 11 42·18	−1 55·68	29·11	1	⊙ ⊙
4	S 6413 S 6443	27 33 30 33	28 44 34·14 35 5 11·99	−2 23·69	29·38	1	⊙ ⊙
5	S 6473 S 6484	33 4 33 33	30 41 28·17 33 4 46·20	−0 38·52	28·66	1	⊙ ⊙
6	R 3040 S 6573	37 59 41 55	3 1 1·55 60 39 0·97	+2 26·79	28·05	1	⊙ O 1352
7	R 3061 S 6621	43 34 47 18	9 46 56·08 53 52 50·18	+2 35·07	28·20	1	⊙ ⊙
8	S 6626 S 6633	48 7 49 22	33 22 46·30 30 22 48·40	−0 16·27	28·58	1	⊙ ⊙
9	R 3102 S 6667	52 54 53 27	8 1 13·60 55 47 18·44	−1 47·56	28·46	1	⊙ O 1368
10	S 6700 R 3135	11 57 24 12 1 56	52 0 2·03 11 42 43·03	+1 5·65	28·18	1	⊙ ⊙
11	S 6771 R 3156	4 0 6 10	40 42 8·95 23 4 23·69	−0 48·39	27·93	1	⊙ S 6789 O 1390
12	S 6855 S 6863	15 16 16 5	21 38 51·04 42 2 4·32	+2 0·55	28·28	1	O 1407 ⊙
13	S 6889 S 6902	18 44 12 20 18	38 23 3·15 25 27 41·12	−2 53·85	28·29	1	⊙ ⊙

Mean 31° 52′ 28″·43 ± 0″·08.

Table V.

LIST OF FIELD RECORD BOOKS.

a. Base Line Records.—Mr. Simms.

No. of Book.	Description.	
1	Belfast Base	Standards and Wire Comparisons.
2	,, ,, ...	,, ,, ,,
3	,, ,, ...	,, ,, ,,
4	,, ,, ...	Wire Measures.
5	,, ,, ...	,, ,,
6	,, ,, ...	Levelling.
7	Ottoshoop Base	Wire Measures.
8	,, ,, ... Belfast Base	Levelling. Levels between Monument and Station.
9	Wepener Base	Wire Measures.
10	,, ,, ...	Levelling.
11	Kroonstad Base	Wire Measures.
12	,, ,, ...	Levelling.
13	,, ,, ... Houts River Base	Wire Measures. Levelling (3rd Measure).
14	,, ,, ,, ...	Wire Measures.
15	,, ,, ,, ...	Levelling (1st and 2nd Measures).
15A	Copies of Base Line Records (incomplete).	

b. Ground Standards.—Mr. Robinson.

16	Pretoria	Public Buildings.
17	,, ...	Racecourse.
18	Johannesburg	Joubert Park.

c. Comparison of Bars.

19	Mr. Robinson.
20	Mr. Cochrane.
21 22 23	Colonel Morris and Mr. Robinson.

d. Horizontal and Vertical Angles.

No. of Book.	Observer.	Stations.		
24	Col. Morris ..	Ottoshoop Base Extension.		
25	Mr. Simms ..	Cable Hill. Nooitgedacht I. Blijvooruitzicht. Observatory Hill.	Paardekop II. Elands Kop I. Witkop II. Vliegenkraal.	Rhenosterkop II. E. End Kroonstad. W. ,, ,, Braunzijn Kop (pt.).
26	,, ..	Braunzijn Kop (pt.). Boschrand. Doornkop.	Liebenberg Stroom. Spitzkop II.	Elandskop I. Elandskop II.
27	,, ..	Cable Hill to W. End Kroonstad.—Sight and watch telescope pointings.		

Table V—*continued.*

LIST OF FIELD RECORD BOOKS—*continued.*

d. HORIZONTAL AND VERTICAL ANGLES—*continued.*

No. of Book.	Observer.	Description.		
28	Mr. Simms ..	Kaffir Kop. Rietfontein. Mijnhardt's Rust.	Zwartkrans. Rhebokberg.	Mabula. Machache.
29	" ..	Thaba Putsua. Thaba Tsuen. Dikhoele.	Jammersberg. N. End Wepener.	
30	" ..	S. End Wepener. Gobo Gobo. Aasvogel Berg.	Nthodimonate. Helvelyn.	Waschbank Peak. Bendearg.
31	" ..	Xuka.	Cweeweni.	Lubisi.
32	" ..	*S. End Houts River. Pont. Dogola. *Also Astronomical Observations.	Dwarsberg. *Blaauwberg.	*Lejuma. *Loskop II (part).
33	" ..	Loskop II (pt.). Kameelkop.	*N. End Houts River. Matala.	Portugal. *Schnell's Kop.
34	" ..	Iron Crown. Manoutsa.	Thama Koosh. Mount Anderson.	Verloren Vlei. Tafelkop (D.K.).
35	" ..	Duplicate Records (on paper) of books (25-34).		
36	Capt. Gordon..	Salt Lake. Inkwelo.	Nthabankulu. Hlamimpesiberg.	Langberg I. Elandsberg III (part)
37	" ..	Elandsberg III (part). Blaauwkop.	Spitzkop I. Tafelkop (E.) (part).	
38	" ..	Tafelkop (E.) (part). Sterkfontein.	Vlakfontein. Baatjes Bult.	
39	" ..	Tafelkop (D.K.). Wonderfontein.	Baatjes Bult. Verloren Vlei.	Belfast.
40	" ..	Panplaats. Groot Riet Vlei.	Paardekop. Quaggafontein.	Rhenosterkop I.
41	" ..	Cable Hill. Vergenoeg. Witkop. Onverwacht.	Enzelberg. Kaalkop I. Tafelkop. Pilandsberg.	Nooitgedacht I. Boshofsberg. Zwartkloof.
42	" ..	Nthabankulu.	Salt Lake.	Inkwelo (2nd visit).
43	" ..	Drakensberg. Gemsbokberg.	Hermitage. Kaalkop II.	Vaalbank Kop.
44	" ..	Vierfontein. Langberg II.	Kaffir Kop. Elandskop II.	
45	"	Rhenosterkop II. Nooitverwacht. Braunzijn Kop. Zoetvlei. Theron's Kop. Schoongezicht.	Biesie Pan. Bosberg. Weltevreden. Kareelaagte. Du Plessis Dam. Boshof Hill.	Rondefontein. Aasvogel Kop. Tarantal Kop. Paardeberg. Scholtz Kop.
46	"	Orange River. Besters Kop. Wonderkloof. Boschjes Pan. Platkop.	Luipers Rand. Fauresmith Hill. Lokshoek. Drie Baden. De Put.	Lemoenfontein. Koesberg. Aasvogel Berg. Gobo Gobo. Jammersberg.

Table V—*continued.*

LIST OF FIELD RECORD BOOKS—*continued.*

d. HORIZONTAL AND VERTICAL ANGLES—*continued.*

No. of Book.	Observer.	Stations.
47	Capt. Gordon..	Pretoria to Johannesburg, secondary chain.
48 to 58	„	Duplicate records of books 36 to 47 inclusive.
59	Capt. Ley ..	Aasvogel Kop. Tarantal Kop. Kameel Pan II. Spion Kop. Boshof Hill. Zwartkop II. Boesmanskop. Leeuwlaagte. Uitkyk. Winterhoek. Bethel Pella. Boomplaats. Houtnek. Langvallei.
60	„	Schoonheid. Never Mind. Kopje Enkel. Kameelpan I. Smitskraal. Nooitgedacht II. Amsterdam. Klipkuil. Doornhoek. Holpan. Panfontein. Morgenzon. Makouws Kop. Strappan. Doornbult III. Rosalie. Rietpan. Doornbult II.
61	„	Simonsvlei. Zwart's Rust. Boschpan. Karreekuil. Driekuil. Disselboom Pan. Middelbult. Makoeies Pan. Doornbult I. Sypherpan. Houthaal Boomen. Welvediend De Paarl. Bethlehem. Polfontein. Grootfontein. Malapo's Oog. Witkop I. Klippan. Vergenoeg.
62	„	Middelbult. Driekuil. Leeuwfontein. Rhenoster Berg Hoek Schietfontein. Doornplaats. Klerksdorp. Vlaklaagte. Paradijs. Bovenlands Plaats. Nooitverwacht.
63 to 66	„	Duplicate records of books 59 to 62 inclusive.
67	Mr. Cochrane .	Camp, Meintjes Kop, Koedoespoort, Muckleneuk.

e. ASTRONOMICAL OBSERVATIONS.

No. of Book.	Observer.	Stations.
68	Col. Morris ..	S. End Belfast Base, Mare's Kop.
69	„	S. End Belfast Base (Horizontal Angles).
70	„	Mare's Kop, N. End Belfast Base, Langekloof, also Horizontal and Vertical Angles.
71	„	Observatory Hill (Johannesburg).
72	„	Boschrand, Orange River, Driekuil.
73	Mr. Simms ..	Wepener Base extension to Lubisi.
74	Capt. Gordon..	Inkwelo. Gemsbokberg. Hermitage. Kaalkop II. Vaalbank Kop. Vierfontein. Salt Lake.
75	„	Braunzijn Kop, Zoetvlei, Therons Kop, Schoongezicht.
76	„	Meintjes Kop, Muckleneuk.
76A	Mr. Simms ..	Duplicate Records, Northern chain.

Table V—*continued.*

LIST OF FIELD RECORD BOOKS—*continued.*

f. GEODETIC LEVELLING.

Delagoa Bay to Malelane.—Mr. Löwinger.

No. of Book.	Distances.	No. of Book.	Distances.
77	To kilo. 4·5	85	To kilo. 77·1
78	„ „ 12	86	„ „ 87·7
79	„ „ 23	87	„ 61½ miles
80	„ „ 32	88	„ 67¼ „
81	„ „ 34	89	„ 73 „
82	„ „ 49·2	90	„ 79¼ „
83	„ „ 58·6	91	„ 85 „
84	„ „ 66·6	92	„ Malelane, BM 9.

Machadadorp to Balmoral.—Mr. Cochrane.

No. of Book.	Distances.	No. of Book.	Distances.
93	To 201¾ miles	98	To 252 miles
94	„ S. End Belfast Base	99	„ 262 „
95	„ 218 miles	100	„ 273¼ „
96	„ 230¼ „	101	„ 285¼ „
97	„ 240½ „	102	„ Balmoral, BM 014.

Balmoral to Pretoria.—Mr. Löwinger.

No. of Book.	Distances.	No. of Book.	Distances.
103	To 308½ miles.	106	To 345½ miles. „ B.M. 25 in Govt. Buildings, Pretoria } Also personality observations.
104	„ 321¼ „	107	
105	„ 334½ „		
108	Second measure Pretoria Station to B.M. 25. Also Pretoria to Irene.		

Germiston to Potchefstroom.—Mr. Löwinger.

No. of Book.	Distances.	No. of Book.	Distances.
109	To 16½ miles.	113	To 73 miles.
110	„ 31¼ „	114	„ 91½ „
111	„ 37 „	115	„ 93¼ „ BM 47.
112	„ 56 „		

Germiston to Kroonstad.—Mr. Löwinger.

No. of Book.	Distances.	No. of Book.	Distances.
116	To 691¼ miles.	121	To 620 miles.
117	„ 678¼ „	122	„ 604¾ „
118	„ 655½ „	123	„ 590 „
119	„ 650¼ „	124	E. End Kroonstad Base.
120	„ 636 „		

Malelane to Machadadorp.—Mr. Löwinger.

No. of Book.	Distances.	No. of Book.	Distances.
125	To 100¾ miles.	130	To 168¼ miles.
126	„ 113¼ „	131	„ 181¾ „
127	„ 123¼ „	132	„ 189 „
128	„ 139½ „	133	Machadadorp, BM 01.
129	„ 153 „		
134	Repetition of BM 0 to BM 1. (First measure, book 77).		

Table V—*continued.*

LIST OF FIELD RECORD BOOKS—*concluded.*

GEODETIC LEVELLING—*concluded.*

Germiston to Irene.—Mr. Löwinger.

No. of Book.	Distances.	No. of Book.	Distances.
185	To 370¼ miles.	186	Irene, BM 26.

Mr. Cochrane.

No. of Book.	Description.
187	BM 33 (Park Station) to Observatory Hill (Johannesburg), Beacon.
188	BM 024 (Pretoria) to Muckleneuk Beacon.
139 to 144	Duplicate records of books 77 to 82 inclusive.
144A	Some duplicate records on paper.

g. MISCELLANEOUS.

145	Observations made at Headquarters.
146	Experimental levelling observations, and comparison of Thermometers, 1904, July 12.
147	Standardization of Level Staves.
148	Value of divisions of levels by level Tester at R.O. Cape

Table W.

LIST OF COMPUTATION RECORDS.

BOOKS.

a. Base Lines.

No. of Book.	Description.	
1	Belfast Base ..	Reduction to horizontal and reduction of Wire measures.
2	Belfast Base ..	Reduction to horizontal.
3	Belfast Base ..	Reduction to horizontal and reduction of Wire measures.
4	Belfast Base .. Ottoshoop Base ..	Reduction of Wire measures.
5	Ottoshoop Base .. Wepener Base .. Kroonstad Base.. Houts River Base	Reduction of Wire measures.
6	Ottoshoop Base ..	Reduction to horizontal.
7	Wepener Base ..	Reduction to horizontal.
8	Kroonstad Base..	Reduction to horizontal.
9	Houts River Base	Reduction to horizontal.

b. Horizontal Angles.

10	Reduction of Col. Morris' observations.
11	„ „ Mr. Simms' „
12	„ „ Capt. Gordon's „
13	„ „ Capt. Ley's „
14	Adjustment of Figures.

c. Vertical Angles.

15	Reduction of Vertical Angles, Book 1.
16	„ „ „ Book 2.
17	Calculation of Vertical Heights.
18	Adjustment „ „

d. Computation of Triangles.

19	Abstract of Horizontal and Vertical Angles.
20	Spherical Excess, Triangular Errors, Approximate Lengths of Lines, Final Angles and Computation of Sides.

e. Circuit Solution.

21	Latitudes, Longitudes and Azimuths, Preliminary.
22	Spheroidal Co-ordinates, Data for Circuit Solution, Book 1.
23	„ „ „ „ „ Book 2.
24	„ „ „ „ „ Book 3.
25	Latitudes, Longitudes and Azimuths, Final, Book 1.
26	„ „ „ „ Book 2.

Table W—*continued.*

LIST OF COMPUTATION RECORDS—*continued.*

f. ASTRONOMICAL.

No. of Book.	Description.
27	Computation of Astronomical Azimuths.
28	" " " Latitudes.

g. GEODETIC LEVELLING.

29	Reduction of Mr. Löwinger's observations, Book 1.
30	" " " " Book 2.
31	" " " " Book 3.
32	" " " " Book 4.
33	Reduction of Mr. Cochrane's observations.
34	Heights of Bench Marks.

h. ROUGH FIELD COMPUTATIONS.

35	Capt. Gordon.
36	Mr. Löwinger.
37	Mr. Cochrane.

PAPERS

j. BASE LINES.

No. of Packet.	Description.
38	Reduction to Mean Sea Level of all Bases.
39	Ground Standards, Johannesburg and Pretoria.

k. HORIZONTAL ANGLES.

40	Abstracts, Spherical Excess, Approximate Lengths of Lines.
41	Adjustment of Figures.

l. VERTICAL HEIGHTS.

42	Adjustment of Vertical Heights, Capt. Léy's chains.

m. PROBABLE ERRORS.

43	Probable Errors, Horizontal Angles and Vertical Heights.

Table W—*continued.*

LIST OF COMPUTATION RECORDS—*continued.*

n. CIRCUIT SOLUTION.

No. of Packet.	Description.
44	Data for Adjustment.
45	Solution of Normals.
46	Correction to Co-ordinates, Corrected Co-ordinates, Latitudes, Longitudes and Azimuths from Co-ordinates.

o. ASTRONOMICAL.

47	Reduction of Azimuth Observations.
48	" " Latitude "

p. BARS.

49	Reduction of Bar Comparisons, 1905 and 1906.

q. GEODETIC LEVELLING.

50	Abstracts of Heights of Bench Marks (incomplete).
51	Field Computations.

r. SWAZILAND TRIANGULATION.

52	Computations of Latitudes, Longitudes, Azimuths and Spheroidal Co-ordinates.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS.

GROUP I.—KIMBERLEY TO OTTOSHOOP.

* Bracketed numbers are the numbers cut on the beacon.

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Aasvogel Kop ..	162	Frankfort. 584 ..	Mrs. Barlow ..	Boshof	Boshof, 17 m. N.E.; Kimberley, 15 m. S.W.	Water at dam near house. Beacon on highest point of conspicuous tafel kop 1 m. W. of Boshof—Kimberley road.
Tarantal Kop	152	Bakenskop. 428 ..	John Steyn ..	Kimberley, C.C. ..	Kimberley or Boshof, about 16 m.	Water bad in dams seen from beacon. Beacon 6 yds. S.W. of boundary between Griqualand and O.R.C.
Boshof Hill	165	Leeuwfontein. 10 ..	J. P. Celliers ..	Boshof	Boshof, about 3 m. E. ..	Water at farm house. Beacon on highest point of flat-topped kop W. of Boshof, known as Zwart Kop.
Spion Kop. (2)* ..	166	Gannalaagte. 469 ..	De Wet	Boshof	Boshof, 14 m.; P.O. Leeuwkuil; S.A.C. Zevenfontein	Water at homestead. Beacon 60 yds. and 99° magnetic bearing from old farm. Beacon at N.W. end of kopje ½ m. N. of Bakenskop—Boshof road.
Kameelpan II. (1) ..	167	Kameelpan. 458 ..	Van Zyl	Boshof	Boshof, 16 m.; P.O. Leeuwkuil; S.A.C. Zevenfontein	Water-pump at homestead. Beacon in line with E. edge of Kaffir Hut and Tarantal Kop. T.S. beacon 515 yds. from former.
Zwart Kop II. (3) ..	183	Grootvallei. 349 ..	J. P. Minaar ..	Boshof	Boshof, 6¼ m. S.E.	Water at Putfontein 2⅓ m. W. Beacon on highest point of small rocky kop, ⅓ m. N. of road from Zevenfontein to Grootvallei.
Boesmans Kop. (4) ..	184	Boesmans Kop. 300..	A. J. Du Plessis ..	Boshof	Boshof, 18 m. S.E.	Water at Remuneration 2 m. N.W. Beacon 28 yds. from S. edge of small oval kop, 100 yds. E. of road from Boesmans Kop to Remuneration.

Group I.—Kimberley to Ottoshoop—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Uitkyk. (6)	185	Uitkyk. 87	L. A. Beck ..	Boshof	Boshof, 16½ m. S.	Water at homestead ½ m. S.E. Beacon on highest point, 72 yds. from N.W. and 130 yds. from S.W edge of northern of two kopjes, 1 m. apart, on high bult.
Leeuwlaagte. (5) ..	186	Leeuwlaagte. 318 ..	Thomas Foster ..	Boshof	Boshof, 20 m. S.S.E.; S.A.C. Zevenfontein, 12 m. S.	Water at homestead 2 m. E.N.E. Beacon 90 yds. from steep edge on W end of N. side of high wooded bult 2¼ m. from farm house.
Winterhoek. (7) ..	187	Winterhoek. 95 ..	Oates	Boshof	Christiana; J.P. at Christiana Drift; P.O. at Rietvlei, 14 m. N.E.	Water at homestead. Beacon on N. end of long flat-topped ridge running N.N.W. from Uitkyk.
Boomplaats. (8) ..	188	Boomplaats. 477 ..	P. Yost	Boshof	Christiana; J.P. at Christiana Drift; P.O. Rietvlei	Water at homestead 1¼ m. S. Beacon on N. side of bush-covered ridge in N.W. angle of farm, ½ m. from N. fence and ¾ m. from W. fence.
Houtnek. (10) ..	189	Houtnek. 325 ..	Dr. Gillespie ..	Boshof	Christiana; J.P. at Christiana Drift; S.A.C. Rietvlei; P.O. Rietvlei, 3½ m. S.	Water at homestead. Beacon on high open bult to S. of house and close to footpath from Rietvlei farm.
Bethel Pella. (9) ..	190	Bethel Pella. 623 ..	A. J. Wolhuter ..	Boshof	Christiana; J.P. at Christiana Drift; S.A.C. Smitskraal; P.O. Rietvlei	Dam and well ¾ m. E., and Vaal River 2 m. Beacon on highest point of low ridge in flat plain, 315 yds. from bush on N. of road and 800 yds. N.W. of edge of dry pan ¾ m. from house.
Schoonheid. (12) ..	191	Schoonheid. 170 ..	Transvaal Government	Bloemhof	Christiana, 5½ m. S.E.; S.A.C. Blesbokfontein	Water at Kaffir huts 3 m. W. Beacon on high open bult 2,016 yds. N. of S.E. farm beacon, and 550 yds. W. of N.S. fence.
Langvallei (11) ..	192	Langvallei. 450 ..	C. G. van der Merwe and 10 others.	Boshof	Christiana; J.P., Christiana Drift; S.A.C. Rietvlei.	Vaal River 2½ m. N.W. Beacon on long, high, wooded ridge running out from high ground N.E. of Houtnek to Vaal River ¾ m. from E. fence and 2¼ m. from river.

Descriptive List of Trigonometrical Stations—*continued.*

Group I.—Kimberley to Ottoshoop—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Never Mind (13) ..	193	Never Mind. 188 ..	McEvoy	Bloemhof	Christiana, 14½ m. S. ..	Water at Kaffir Stad 1 m. W. Beacon on highest ground in neighbourhood, about 1 m. E. of road to Kameelpan and bearing 92° magnetic from dam on road.
Kopje Enkel (15) ..	194	Kopje Enkel. 305 ..	Burgers	Bloemhof	Christiana, 16m. S.S.W. ..	Water at homestead, ½ m. S. Beacon on solitary Kop 18 yds. E. of boundary beacon C.C. and Transvaal.
Kameelpan I. (14) ..	195	Kameelpan. 90 ..	D. P. Verwey ..	Bloemhof	Christiana, 20 m.; S.A.C. Holwater.	Water at homestead, 1 m. E.S.E. Beacon on small pointed kop 1 m. W.N.W. of N. dam near homestead and 1½ m. S. of Klaas.
Smitskraal (16) ..	196	Smitskraal. 294 Sweet William. 14 Fort Weber. 212	A. A. van Niekerk; New Cons. Gold Farms; Badenhorst.	Bloemhof	Christiana; P.A. and S.A.C. Honeys Kop, 8½ m. N.N.W.	Water at Tweelingspan 3½ m. W. Beacon at corner beacon of farms.
Nooitgedacht II. (18)	197	Nooitgedacht. 295 ..	Coetzee	Bloemhof	Christiana or Schweizer-Reineke; P.A. Honeys Kop.	Water at homestead. Beacon 670 yds. S.W. of corner beacon of Lerouxpan, Vryheid and Nooitgedacht.
Amsterdam (17) ..	198	Amsterdam. 243 ..	Mr. Mana	Bloemhof	Christiana or Schweizer-Reineke; P.A. Honeys Kop, 3½ m.	Water at homestead. Beacon on bush covered hill marking highest ground of long ridge running N.E. above Harts River valley, 1 m. W. of road from Fort Weber to Niekerks pan.

Group I.—Kimberley to Ottoshoop—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Klipkuil (20) ..	199	Klipkuil. 322 ..	Sonnekus	Bloemhof	Schweizer-Reineke; P.A. Honeys Kop.	Dam below homestead. Beacon on small narrow stone kopje known as Boschkop just N. of Klipkuil house, or highest point in centre of kop, 220 yds. from S. end and 60 yds. from E. and W. sides.
Doornhoek (19) ..	200	Doornhoek. 88 ..	J. F. de Beer ..	Bloemhof	Schweizer-Reineke; P.A. Goudplaats.	Water at Balmoral homestead (1¾ m.). Beacon on a knoll ½ m. away from and bearing W.N.W. from highest point on road running S.W. from Doornhoek farmhouse to Balmoral.
Holpan (21)	201	Holpan. 62	McEvoy	Bloemhof	Schweizer-Reineke, 5½ m. ..	Water in pan 1 m. N.E. A road runs W.S.W. from ruin near two pans and has greatest elevation 1,800 yds. from house. From this point 40 yds. to W. is the beacon.
Morgenzon (23) ..	202	Lots. 15 and 16 ..	De la Rey	Bloemhof	Schweizer-Reineke, 8 m. ..	Water at homestead 2 m. S.W. Beacon close to W. edge of Lot 16, Townlands. Schweizer-Reineke on N. side of road to Vryburg, at highest point of large hill parallel to road.
Panfontein (22) ..	203	Panfontein. 98 ..		Bloemhof	Schweizer-Reineke, 5 m. ..	Water at Pretorius Rust or pan 1¾ m. S.S.W. Beacon on bush covered ridge 3¼ m. N.E. of Holpan and 1¼ m. W. of pan and house Pretorius Rust.
Makouws Kop (24) ..	204	Makouwspan. 83 ..	H. A. Nieuwhoud	Bloemhof	Schweizer-Reineke	Water at Biesielaagte 4 m. S.W. or pan 60 yds. E., a road runs N. from Biesielaagte, 3 m. along are old Boer trenches and ridges on left. 40 yds. S. of nearest of these ridges, take bearing 101° and 1,400 yds. away along this bearing at highest point is the beacon. Bush covered ridge.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP I.—KIMBERLEY TO OTTOSHOOP—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Strappan. (25) ..	205	Strappan. 232 ..	G. D. Smith ..	Bloemhof	Schweizer-Reineke; P.O., T.O., Poortje.	Water at Poorte 2½m. E. Beacon on wide open bult in pan country W. of Harts R. Road from Poortje to Palmietfontein; 3 m. along a road branches to W.S.W., rising and crossing grassy pan. From here Beacon is 1¼ m. S.E.
Doornbult III. (26) ..	206	Kareefontein, renamed Doornbult.	..	Bloemhof	Schweizer-Reineke P.O., T.O., Poortje.	Water in pan W. of red house, Graspan or Harts River 6 m. Beacon on S. edge of high, very flat bult, 700 yds W. of old mud kraals, 1,400 yds. N. of house, and about 600 yds. N. of bushy small pan.
Rosalie. (27)	207	Rosalie. 80	Transvaal Government.	Bloemhof	Schweizer-Reineke, P.O., T.O., Poortje.	Water at Graspan 1¼ m. E.N.E. Beacon is W. of N. of Doornbult III, and 1 m. away from it.
Rietpan. (28).. ..	208	Rietpan. 83	Transvaal Consolidated Lands, Ltd.	Lichtenburg ..	Geysdorp or Schweizer-Reineke, J.P.; S.A.C. and P.O. at Barberspan.	Water at homestead. Beacon on highest point of small kop on S.E. edge of dry pan on Poortje-Barberspan road.
Doornbult II. (29) ..	209	Doornbult. 197 ..	B. G. van Rooyen	Lichtenburg ..	Geysdorp and Barberspan ..	Water in spruit 2 m. S., or pan ¾ m. N. Beacon on side of long flat spur E. of Harts River above Rietfontein.
Simon's Vlei. (30) ..	210	Simonsvlei. 21 ..	P. Kirsten.. .. C. J. Kirsten	Wolmaranstad ..	Wolmaranstad (Rietfontein, 14 m. N.W.).	Water at Graspan, 3 m. S.W., and Brakpan 4 m. S. Beacon 150 yds. N. of large solitary thorn tree on long ridge N.E. and S.W. extension from Graspan ridge.

GROUP I.—KIMBERLEY TO OTTOSHOOP—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Zwart's Rust. (31)	211	Swart Rust. 87	Le Roux	Lichtenburg	Wolmaranstad, Korannafontein or Barberspan.	Water in dam ½ m. W. of red house. Beacon on high bush covered ridge ½ m. N.N.W. of red brick farm house.
Boschpan. (32)	212	Boschpan. 274	W. H. Joubert S. N. Papenfus G. I. van Niekerk	Lichtenburg	Wolmaranstad, Barberspan; P.A. at Boschpan.	Water at homestead 4 m. S.E. Beacon on long flat-topped wooded ridge from Steynspan E.S.E. to Boschbult, and joining that from Doornbult N.N.E.
Karreekuil. (33)	213	Kareekuil. 143	H. Vermaas	Lichtenburg	Wolmaranstad, Barberspan or Korannafontein (P.A.)	Water at Korannafontein 3 m. Beacon on N.W. end of ridge ending in a bluff 270 yds. S. of corner beacon of Kareekuil and Korannafontein.
Disselboompan. (34)	214	Disselboompan. 244	A. W. Baken M. J. van Dyk	Lichtenburg	J.P. at Barberspan, P.O. and S.A.C. Biesjesvallei.	Water at Rietspruit 4 m. S.S.E. Beacon on high bult N.N.E. and S.W., 4 m. N.W. of Reitspruit, highest point on ridge, and surrounded by scattered clumps of bush.
Driekuil. (35)	215	Driekuil. 134	G. Otto	Lichtenburg	Haartebeestfontein or Korannafontein, P.A.	Dam 1½ m. S.W., spruit 2 m. Beacon on N.W. end of long kopje 5 m. N.E. of Korannafontein.
Middelbult. (36)	216	Middelbult. 239	N. M. Grobelaar P. E. Smith H. W. Schutenburg	Lichtenburg	Lichtenburg, Biesjesvallei, Rooi-randjesfontein, 4 m. N.N.E.	Water in Klein Harts River, 1½ m. S. Beacon 200 yds. W. of small road from Klein Harts River to Wesselspoort, where it crosses main road from Rooi-randjesfontein.
Makoiespan. (37)	217	Makoiespan. 61	H. J. Greef J. H. De la Rey	Lichtenburg	Lichtenburg, Biesjesvallei	At Homestead, 2 m. S.S.E. Beacon near S.E. corner of large tract of bush 60 yds. N.E. of road from Vlakplaats at point 220 yds. from where road enters bush.
Doornbult I. (38)	218	Doornbult. 60	K. Kirsten J. J. and F. J. Jacobs.	Lichtenburg	Lichtenburg, 11 m. N.E.; Biesjesvallei.	Dam on road 1¼ m. S.S.E. Beacon on small hill overlooking Harts River on S. side, and 2 m. N.W. of Kaffir location on Rhenosterdoorns, and ¼ m. E.S.E. of corner beacon.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP I.—KIMBERLEY TO OTTOSHOOP—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Bethlehem. (39) ..	219	Bethlehem. 33 ..	Transvaal Prop. Company.	Lichtenburg ..	Lichtenburg	Well at homestead 3 m. N.W. Beacon 220 yds. N. of small road from Kaalfontein to Bethlehem house 3½ m. from Kaalfontein.
De Paarl. (42) ..	220	De Paarl. 62 ..	F. C. Eloff .. .. J. Eloff.	Lichtenburg ..	Lichtenburg, 7 m.	Pan 2 m. W.N.W. Beacon on highest point of low kopje on E. of road from Lichtenburg to Potfontein.
Houthaal Boomen. (40)	221	Houthaal Boomen. 208	Doveton G.M. Co...	Lichtenburg ..	Lichtenburg	Water at S.A.C. barracks, 5 m. S.E. Beacon on highest point in long ridge, running E. and W. 400 yds. S.E. of large patch of thorn-bush, 6 m. N.E. by N. from Lichtenburg.
Sypherpan. (41) ..	222	Sypherpan. 72 .. Doornhoek. 39 .. Kaalfontein. 6 ..	W. J. Retief .. J. B. Roode Z. P. le Roux	Lichtenburg ..	Lichtenburg	Water at Kaalfontein 2 m. N.E. Corner beacon of three farms.
Welvediend. (43) ..	223	Welvediend. 249 ..	African and European Investing Co.	Lichtenburg ..	Lichtenburg, 12 m. S.A.C. Uitgevonden	Water at Wondergat 4 m. N. on road. Beacon on small kop 1 m E. of Lichtenburg to Zeerust road.
Malopos Oog. (44) ..	224	Molopos Oog. 286 ..	Kotze	Marico	Zeerust and Ottoshoop, 9 m. N.N.W.	Vlei 2 m. S.W. Beacon on highest of small kops N.E. of the vlei, forming the source of the Molopo river.
Polfontein. (45) ..	225	Polfontein. 254 ..	Transvaal Government	Lichtenburg ..	Lichtenburg; Rooigrond P.O.	Water at homestead 3 m. S.W. Beacon near small solitary tree ¼ m. N. of small old road from Polfontein N.E. to dry Molopo river 2½ m. from Polfontein, 1½ m. from Mafeking—Lichtenburg road.

Group I.—Kimberley to Ottoshoop—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Grootfontein. (46) ..	226	Grootfontein. 81 ..	Coetzee	Lichtenburg ..	Rooigrond; Mafeking; S.A.C. Doornplaat	Water at homestead 1¼ m. N. Beacon on wide open bult 500 yds. E. of branch road from Mooimeisjesfontein to Grootfontein, and 1¼ m. S. of latter.
Klippan. (47).. ..	227	Klippan. 194 ..	Lewis & Marks ..	Marico	Zeerust or Ottoshoop ..	Water at ruins 2 m. S.S.E. Beacon on small kop just S. of corner beacon of Twyfelshoek and Zondagspan.

Group II.—Wolmaranstad to Kroonstad.

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Leeuwfontein. (48) ..	228	Leeuwfontein. 140 ..	L. D. Swanepoel ..	Lichtenburg ..	Lichtenburg; S.A.C., J.P., P.O., and T.O. at Haartebeestfontein 10 m. S.E.	Water in dams and spruits on farm. Beacon near W. end of long highridge, 10 m. N.W. of Haartebeestfontein, 70 yds. S.E. from a stone beacon and 100 yds. from N. edge of hill.
Schietfontein. (49) ..	229	Schietfontein. 122 ..	Bros. C. K. & N. Swanepoel	Wolmaranstad ..	Wolmaranstad and Haartebeestfontein 15 m. N.E.	Water in fontein at Rietfontein 1½ m. N. of point. Beacon in middle of long ridge from Vlakfontein to Sypherfontein. S., and parallel to and 1 m. from upper portion of Rhenoster Spruit.
Rhenosterberg Hoek. (50)	230	Rhenosterberg Hoek. 625	W. L. Jooste ..	Klerksdorp ..	Klerksdorp and Haartebeestfontein 12½ m. E.S.E.	Water in holes in upper part of spruit 1¾ m. N.E. Beacon on highest point of horse-shoe shaped ridge 1¼ m from main spruit below Haartebeestfontein, 10 yds. N.W. of masonry mining beacon.
Doornplaat. (52) ..	231	Doornplaat. 124 ..	Transvaal Mines, Ltd.	Wolmaranstad ..	Klerksdorp; store and P.O. at Rhenoster Spruit .	Water at Yzerspruit 3 m. S. Beacon very near boundary line between Yzerspruit and Doornplaat, and little N. of main road—Klerksdorp to Bloemhof.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP II.—WOLMARANSTAD TO KROONSTAD—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Klerksdorp. (51) ..	232	Town Lands.. ..	Klersdorp G. and D. Mining Co.	Klerksdorp ..	Klerksdorp 1 m. N.W. ..	Water at mine buildings or at railway station. Beacon on small stony ridge close to mine.
Vlaklaagte. (V) ..	233	Altonea, portion of Vlaklaagte. 478	O.R.C. Government. Occupier: Mandy	Bothaville S.D., Kroonstad	Klerksdorp (by rail from Vierfontein 10 m. N.E.); J.P. at Bothaville	Water in wells near house. Beacon 600 yds. N.N.E. of house, and 250 yds. S.W. of isolated tree. Beacon on raised concrete platform.
Paradijs. (P).. ..	234	Paradijs. 137 ..	Mr. King	Bothaville S.D., Kroonstad	Klerksdorp via Vierfontein; J.P. at Bothaville	Dam at Pretorius' farm. Beacon at highest point towards N.E. end of conspicuous stony hill, 8 m. S.W. of junction of Rhenoster and Vaal rivers.
Bovenlands Plaats. (B)	235	Dubbelpan. 366 ..	Cooke and The Pilgrims Mining Estate Co.	Bothaville S.D., Kroonstad	Bothaville 17 m.	Well and pan at farmhouse. Beacon on high bult 350 yds. E. of main road, and 1¼ m. N.E. of Mr. Cooke's house.

GROUP III.—NEWCASTLE TO BELFAST.

Salt Lake	57	Jubilee Farm ..	Mr. Thomas, Occ: Kaffir Johnstone	Newcastle, Natal..	Newcastle; T.O. Alcocks Spruit 2¼ m.	Water N.W. of beacon in spruit 2 m. from beacon. Beacon on low ridge running N. to S., forming end of range of hills running N.W. to S.E. Hill about 600 ft. above spruit at farm.

GROUP III.—NEWCASTLE TO BELFAST—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Inkwelo	59	Mount Prospect ..	Mr. Payne ..	Newcastle, Natal ..	Newcastle 24 m., S.; Charlestown 12 m. over Laing's Nek; Mount Prospect Station.	Water in spruits near Mr. Payne's house, also on top in kloof S. of beacon. Beacon on conspicuous flat-topped mountain 3 m. S.W. of Majuba.
Nthabankulu	60	Mitzoek. 73 W. ..	Mrs. P. Uys ..	Utrecht	Utrecht 20 m. S.; Wakkerstroom 24 m. N.W.	Camp and water in hollow S. of beacon. Highest point of range halfway between Wakkerstroom and Utrecht, and just North of mountain called Wonderhoogte.
Langberg I.	61	Langberg. 271 ..	N. H. Fick ..	Wakkerstroom ..	Wakkerstroom 18 m. S.E.; Volkrust 18 m. S.W.	Water in valley E. of point. Beacon is 7 yds. S.E. of farm beacon on highest of range of small kopjes 2¾ m. N.W. of Langberg homestead.
Hlamimpesiberg ..	62	Groothoek. 250 ..	W. H. Buhrman J. R. & H. T. „	Wakkerstroom ..	Wakkerstroom 27 m. S.W.; Telephone and Post Agency at Van der Poel's store on main road.	Water ¼-m. N. of beacon at source of spruit. Beacon is on highest point of Western end of range which runs E. and W. from a point about halfway between Wakkerstroom and Piet Retief and North of the Pongola River.
Elandsberg III. ..	63	Kromhoek. 137 .. Elandsberg. 109 ..	Labuschagne A. Robinson	Wakkerstroom ..	J.P. and T.O. at Amersfort 10 m. W.; P.O. at Driefontein store 5 m. S.	Water at homestead. Beacon is on highest point of long flat range forming boundary between Kromhoek and Goedgemoed.
Blaauwkop	64	Vaalkop. 167 ..	J. J. de Jager ..	Ermelo	Ermelo 35 m. N.E.; Amersfort 20 m. S.E.; Post Box at Morgenzon.	Water in valley 1 m. N.E. of point. Beacon is in sangar on highest point of conspicuous hill on N. bank of Vaal River, near junction of Bethel, Standerton, Ermelo and Wakkerstroom districts.
Spitzkop I. (Alkmaar)	65	Spitzkop. 115 ..	J. G. Scheepers ..	Ermelo	Ermelo 27 m. N.W.; P.O. at Rietvlei.	Water at homestead by drift on main road. Beacon on highest point of conspicuous pointed kop.

Descriptive List of Trigonometrical Stations—*continued.*

Group III.—Newcastle to Belfast—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Tafel Kop (Ermelo) ..	66	Van Oudtshoornstroom. 15	A. H. Kleinhans ..	Ermelo	Ermelo 3 m. S.W.	Water from spring at homestead. Beacon on highest point of Tafel Kop, 70 yds S.W. of blockhouse and 23 yds. S.W. of fence.
Sterkfontein	67	Sterkfontein. 275 ..	Rautenbach ..	Ermelo	Ermelo 15 m. S.; Carolina 15m. N.; Breyton 1½ m. N.	Water in spring 500 yds. down S.W. slope. The beacon is situated on the ridge forming the watershed known as Klipstafel, halfway on road between Ermelo and Carolina and 40 yds. on E. side of road.
Vlakfontein	68	Vlakfontein. 46 ..	Nel	Carolina	Carolina 30 m. W.; Lake Chrissie 20 m. S.W.	Water in spring 400 yds. E. of beacon and 100 yds. N. of road. Beacon is on the N. of main road from Carolina to Swaziland, on ridge running through Ferniehaugh and Vlakfontein.
Baatjesbult	69	Haarlem. 58, or Goedeverwachting. 194	S. Marks & Co. Kritzinger	Carolina	Carolina 7 m. N.W.	Water in spring about 500 yds. on S. of main road opposite beacon. Beacon is in centre of site of old stone beacon on left or N. side of main road, Carolina to Swaziland, on top of bult after passing homestead on Goedeverwachting.
Tafel Kop, Duivel's Kantoor	70	Goede Hoop. 114, corner of My Own. 98, Arnoldsberg. 97, Onverwacht. 181, Mooifontein. 98c.	Sir Geo. Farrar ..	Barberton	Kaapsche Hoop 16 m. N.E.; Barberton.	Water in kloof halfway down N.W. side of kop. A conspicuous flat-topped kop at S.W. extremity of Duivel's Kantoor.
Wonderfontein ..	72	Generaal's Draai. 83	Prinsloo	Middelburg ..	Belfast 12 m. E.; Wonderfontein Station.	Water at Station. Beacon 200 yds. N. of pan on N. side of station.

GROUP III.—NEWCASTLE TO BELFAST—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Verloren Vlei	71	Verloren Vlei. 1316	Prinsloo	Lydenburg	Lydenburg or Belfast; Dullstroom, 8 m. S.E.	Water in boggy valley ¾ m. N.W. of beacon. Beacon on S.E. end of ridge on outcrop of rock, on right hand side of road.
Panplaats	73	Panplaats, No. 2. 476	Government Farm, Occupier, H. Wilson	Middelburg	Middelburg and Pan Station	Water at homestead and at store on Oliphantslaagte. Beacon on top of rise about 500 yds. W. of homestead.
Belfast	74	Wemmerhuis. 281	E. Koch	Carolina	Belfast, 2 m. N.W.	Water on N. side of railway line. Beacon on rise S. of station near road to Carolina.
Langekloof	75	Langkloof. 54	J. H. Viljoen	Lydenburg	Belfast, 8 m. SS.E.	Water on stream S.W. of point. Beacon on ridge to left of road, Belfast—Witpoort.
Marés Kop	76	Vlakfontein. 465	Widow Maré	Lydenburg	Belfast 13 m. S.W.	Water in Spruit N. of point. Beacon on prominent kop S. of the source of Crocodile River and N. W. of Machadadorp.
South End, Belfast Base	77	Steynsplaats. 339	Children of late P. Coetzee	Lydenburg	Belfast 1½ m. S.W.	Water in spring on E. of slope. South terminal near Monument.
North End, Belfast Base	78	Moeilykheid. 776	F. J. J. Durand	Lydenburg	Belfast 12 m. S.	Water in spruit N. of point. Terminal pier on rise on western side of road from Belfast to Lydenburg.
Grootrietvlei	79	Grootrietvlei. 116	M. Botha	Middelburg	Middelburg, 24 m. S.W.	Water S.W. in hollow. Beacon on south knoll W. of large pan, 600 yds. S.W. of farm road.
Paardekop I	80	Paardeplaats. 564	H. C. T. Grutzner (unoccupied)	Sekukuni's Ward, Middelburg	Middelburg; Native Commr. at Pogwane, 10 m. N.; Helio to Wonderfontein	Water in kloof 800 yds. S.E. of beacon. Beacon on centre of kop on E. boundary of Paardeplaats in Sekukuni's range.

Descriptive List of Trigonometrical Stations—*continued.*

Group IV.—Belfast to Limpopo.

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Mount Anderson ..	236	Haartebeestlaagte. 155	Lydenburg Estate Company (Ltd.)	Lydenburg ..	Lydenburg, 16 m. W. ..	Water in small spruit on S.W. slope 150 ft. from summit. Beacon on highest point of mountain.
Thama Koosh.. ..	237	Soupiana. 19 ..	Government ..	Lydenburg ..	Lydenburg, 45 m. S.E.; post-box at Schroder's, 5 minutes walk from Mr. Knight's house.	Water in small spring on top ½ m. from point. Beacon on highest point of highest peak in Lulubergen, W. of Steelpoort River.
Manoutsa	238	Edinburgh. 163 ..	E. F. Bourke; B. T. Bourke; F. A. English	Lydenburg ..	Leydsdorp; Native Commissioner at Haenertsburg; P.O. and stores at Ohrigstad	Water down S.W. slope 2,000 ft. below summit. Beacon on highest point of ridge at E. end of Drakensberg, and a little N. of S. boundary stone of Calais and Edinburgh. Also known as Oliphant's Berg.
Iron Crown	239	Lot. 366; Haenertsburg	Transvaal Government	Zoutpansberg ..	Pietersburg, 40 m.; P.O. and J.P. at Haenertsburg, 8 m. N.	Water in spring 1,500 yds. S. of beacon. Beacon on old road about 50 yds. E. of same on highest point of Drakensberg in the district.
Portugal	240	Portugal. 1066 ..	Transvaal Consolidated Lands and Exploring Company, Limited	Waterberg ..	Pietersburg; Piet Potgietersrust	Water in spring in valley 550 ft. below point on W. side. Beacon on highest point of Chunie range on sharp rocky ridge, near beacon of Spanjé, Portugal, and Rietfontein.
Schnells Kop	241	Near Enkeldoorns and Sterkloop	— Goosen; Transvaal Consolidated Lands and Exploring Company, Limited	Zoutpansberg ..	Pietersburg; Haenertsburg, 14 m. S.; Post-box at Woodbush.	Water on E. slope close to point. Beacon on highest point at N. end of small saddle-shaped kop on Woodbush range.

GROUP IV.—BELFAST TO LIMPOPO—*continued.*

Name of Station.	Reference No	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Matala..	242	Matalas Location ..	Natives	Zoutpansberg ..	Pietersburg, 30 m. P.O.; Zandfontein, 3 m.	Water in spring 850 ft. below point on E. slope. Beacon is near large boulder 16 ft. high on cluster of granite kopjes in centre of Matalas Location.
Loskop II	243	de Loskop. 127 ..	Transvaal Consolidated Lands and Exploring Company, Limited	Zoutpansberg ..	Pietersburg, 30 m.; P.O. at Kalkbank, 4 m. from point (Watt's Store)	Water in pools in river bed 1½ m. S.E. of point. Beacon on highest point of small razor-backed range in flat plain on extreme E. tooth-shaped point.
Kameelkop	244	Common to farms Zandput, Persie, and Van Wyksput	..	Zoutpansberg ..	Pietersburg; P.O. at Kalkbank	Water in stream S.W. of point.
South End, Houts River Base	245	Vaalkop. 813 ..	Pauer	Zoutpansberg ..	Pietersburg; P.O. at Kalkbank	Water on either of farms near.
North End, Houts River Base	246	Kalkbank. 128 ..	Occ.: Watts ..	Zoutpansberg ..	Pietersburg; P.O. at Kalkbank	Water in stream ¾ m. N.E.
Blaauwberg	247	The Grange. 1123. Beacon Common to Glenfernis, The Glade Beauley, Grange, Glyn	..	Zoutpansberg ..	Pietersburg, 70 m. S.; Native Commissioner and Govt. P.O., 2 m. S.	Water in stream running through Beauley. Beacon on highest point near N. boundary of Beauley, on highest point of Blaauwberg, called Mariari by Kaffirs.
Lejuma	248	Brinkrust. 2187. Corner beacon of farms Bergplaats, Brinksrust, and Diepkloof.	W. H. A. Cooper..	Zoutpansberg ..	Pietersburg, or Louis Trichardt, 35 m.; P.O., Mara, 8 m. S.	Water in kloof 1,000 ft. below and S.E. of point. Beacon on highest point of Zoutpansberg. N. of Mara.
Dwarsberg	249	Moddergat. 1222 ..	..	Waterberg ..	Pietersburg, 115 m S.E.; Nearest P.O. at Blaauwberg, weekly	Water in pools in river 5 m. from point. Beacon is on highest point of Dwarsberg, called Dowitsal's berg by Kaffirs.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP IV.—BELFAST TO LIMPOPO—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Pont	250	Modena. 1234	..	Zoutpansberg	Pietersburg, 120 m. S.; P.O. and Police at Rhodes Drift, 8½ m. N.	Water in pools in Limpopo River. Beacon on small rocky kop on high ground 4 m. S. of drift.
Dogola	251	Petershof. 1378, and Noanderhole, Zonsbeek, Goeree, and Erfrust.	J. G. and G. Donovan	Zoutpansberg	Pietersburg, 144 m. S.; P.O. at Messina Mine, 25 m. E.	Water in river 2 m. from point. Beacon is on highest of sharp double pointed peak rising from plain.

GROUP V.—BELFAST TO OTTOSHOOP.

Rhenosterkop I	81	Rietfontein. 57	A. J. de Lange	Middelburg	Middelburg, 60 m. S.E.; P.A. at Store, Rietfontein; T.O., Bronkhorst Spring Station	Water near top on West kloof. Beacon is on highest point of N. portion of this very prominent kop.
Quaggafontein	82	Kwaggafontein. 1947	A. C. Duvenhage P. P. Schalkwyk J. F. Joubert A. P. Erasmus	Waterberg	Nylstroom; Piet Potgietersrust, 50 m. N.N.E.; Store at Pogwane, 32 m. E.; Store at Kameelpoort, 40 m. S.W.	Water (not good) at Kaffir Kraal S. of kop, or at river. Beacon on highest point of Western summit, 8 yds. S. of farm beacon.
Zwartkloof	83	Zwartkloof. 2126	P. J. Potgieter Judge Curlewis	Waterberg	Nylstroom; Warm Baths, 6 m. E.	Water in spring in spruit, ¼ way up valley, E. of point, from road. Beacon on highest point, on Southern portion of group of hills on Bads Mountains.

Group V.—Belfast to Ottoshoop—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Cable Hill, Pretoria	84	Wonderboom. 311	Van Hulsteyn	Pretoria	Pretoria, 4 m. S.S.E.	Water can be obtained at houses South of hill, and for animals in Aapies River. Beacon is near highest point W. of Wonderboom Poort, and E. of large blockhouse.
Boshofsberg	85	Sterkfontein. 580	Bowers	Rustenburg	Rustenburg, 70 m. S.S.W.; Warm Baths, 36 m. E.	Water from homestead, 1½ m. N. of beacon. Beacon is on highest part of Southern ridge near boundary between Sterkfontein and Weyhoek.
Nooitgedacht I	86	Nooitgedacht. 121	W. G. Hinds	Krugersdorp	Krugersdorp; P.O. Hekpoort, 3 m. S.	Water in spring in Nek on way up. Beacon near blockhouse on Southern face of Magaliesberg, and W. of path over pass.
Pilandsberg	87	Driefontein. 888	J. Combrink A. de Beer E. Strok	Rustenburg	Rustenburg, 45 m. S.S.E.; Post box at Saulspoort, 8 m. E.	Water in kloofs N. and S. of Beacon at foot of hill. Beacon on highest point of group of hills lying N.N.W. of Rustenburg, and N. of W. end of Magaliesberg. Ascent on N. side from Koedoesfontein (Ramagageen).
Tafel Kop	88	Tafel Kop, portion of Rietfontein. 276	Thompson	Rustenburg	Lichtenburg 30 m. S.W.; Ventersdorp 24 m. S.E.; P.O. Mabalstad	Water at homestead. Beacon on west side of hill, on old heliograph platform.
Kaal Kop	89	Rustvoorbij. 895	Boschoff	Rustenburg	Rustenburg; P.O. at Brakkloof 8 m. S.	Water a long way off in valley N. of hill. Beacon is on top of pointed hill near beacon of farms Rustvoorbij, Winkelhoek and Koornfontein.
Onverwacht	90	Onverwacht. 187	Government	Marico	Zeerust, 10 m. N.W.	Water in spruit ½ m. away, S. of beacon. Beacon on high ridge about 10 m. W. of Great Marico R., and 8 m. N. of the high veld road from Mafeking to Krugersdorp.

Descriptive List of Trigonometrical Stations—*continued.*

Group V.—Belfast to Ottoshoop—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy P.O., T.O., &c.	Remarks.
Enzelberg	91	Ella. 130	Government ..	Marico	Zeerust, 12 m. S.W. ..	Water in kloof halfway down on S. side of hill. Hill has two small spitz kops on it, and beacon is at highest point of S.E. edge.
Wit Kop I.	92	Wit Kop. 288 ..	F. Oats	Marico	Zeerust, 12 m. N ; Ottoshoop, 4 m. W.	Water in shafts of mine. For drinking at farm Buffelshoek 1½ m. N.E. Beacon on small stony kop near beacon Wit Kop—Doornplaats
Vergenoeg	93	Vergenoeg. 3 ..	M. W. Viljoen and others	Marico	Zeerust, 6 m. E.N E ..	Water in valley S.E. of kop and furrow S.W. of point. Beacon near beacon of Wolvekop, Klaarstroom, and Vergenoeg.
North End, Ottoshoop Base	94	Doornfontein. 289 ..	..	Marico	Zeerust, 11 m. N.E.. ..	Water at homestead E. of point.
South End, Ottoshoop Base	95	Kareebosch. 108 ..	..	Marico	Ottoshoop, 2 m. N.	Water in Malmani River.

Group VI.—Pretoria to Cape Colony.

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy P.O., T.O., &c.	Remarks.
Obvervatory Hill, Johannesburg	96	Doornfontein ..	..	Witwatersrand ..	Johannesburg	Water from houses. Beacon on centre of three knolls between Indian Monument and Observatory.
Blijvooruitzicht ..	97	Blijvooruitzicht. 640	Schutter and le Roux	Potchefstroom ..	Potchefstroom, 24 m. S.W.; Banks Station	Water at homestead close by on N.W. Beacon on rocky headland about 15 yards W. of farm beacon, which is one of the dividing beacons of Blijvooruitzicht.

GROUP VI.—PRETORIA TO CAPE COLONY—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Paarde Kop II. ..	98	Schoongericht. 302	D. J. Zeeman and others	Heidelberg ..	Heidelberg, 10 m. E. by N. Meyerton Station.. ..	Water in dam near Mr. Hoon's house. Beacon on conspicuous rocky blunt point—highest point of Zuikerbosch Rand.
Wit Kop II.	99	Wit Kop. 410 ..	J. J. Viljoen and W. H. Steyn	Potchefstroom ..	Parys, 8 m. S.	Water in dam 1¼ m. S. of point close to road. Beacon is on highest point of high hog-backed ridge running parallel and close to S. boundary of farm.
Elands Kop I. ..	100	Elands Kop. 54 ..	Els	Heilbron	Heilbron, 8 m. S.S.W. ..	Water in dam at foot of hill ¼ m. away to S.E. of beacon. Beacon on conspicuous round hill 250 feet high.
Vliegen Kraal.. ..	101	Vliegen Kraal. 91 ..	J. H. Bronkhorst H. J. Bronkhorst F. C. Greef	Vredefort	Vredefort, 12 m. N. by W.; Station, 10 m. N.N.E.	Water in dam at foot of W. slope close to Purchase and Bronkhorst. Beacon on highest point at W. end of ridge close to boundary line and 1¼ m. E. of N.W. beacon of farm.
Spitz Kop II.	102	Spitr Kop. 124 ..	de Kock	Heilbron	Heilbron, 9 m. N.N.W. ..	Water in pools in spruit ½ m. S. of point. Beacon on highest point of sharp-pointed kop, and close to S.E. beacon of farm Spitrkop.
Liebenbergstroom ..	103	Vredeverwag. 634 ..	C. R. Serfontein ..	Lindley	Lindley, 20 m. S.S.E.; Paardekraal, 9 m. N.N.W.	Water in spring on E. slope, on farm Drupfontein, ½ m. N. of beacon. Beacon is 15 yds. N.W. of boundary stone of Vredeverwag, Liebenbergstroom, and Drupfontein.
Doornkop	104	Welgeluk. 285 ..	C. H. Kleinhans 5 other Swanepoel " and Swart	Kroonstad.. ..	Kroonstad, 8 m. W.S.W. ..	Water in small dam near farm house on Welgeluk, also spring 1½ m. N.E. of point near farm Klipfontein. Beacon on highest point of high veld ridge covered at W. end with thorn bushes.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP VI.—PRETORIA TO CAPE COLONY—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Rhenoster Kop II	105	Rhenosterspruit. 632	W. H. Geldenhuis J. A. Geldenhuis	Kroonstad	Kroonstad, 12 m. S.E.	Water at Rhenosterspruit 2 m. S. Beacon near junction of farms Rhenosterspruit, Morgenster, and Belmont, 5 yds. E. of farm beacon.
Boschrand	106	Elandsrand. 121	Brink	Kroonstad	Kroonstad, 7 m. N.N.E.	Water at dam 500 yds. E. of point and 60 ft. below. Beacon is on the highest part of ridge 2,000 yds. N. of Boschrand Station.
Braunzijn Kop	107	Braunzijn Kop	Mrs. du Plessis	Kroonstad	Kroonstad, 25 m. N.E.	Water at homestead. Beacon on N. end of wooded hill about ¾ m. E. of homestead.
West End, Kroonstad Base	108	Tweedronk. 783	..	Kroonstad	Kroonstad, 12 m. W.S.W.	Water at farm about ¼ m. N.E. Beacon 6 m. W. of Valsch River near Kaffir kraal.
East End, Kroonstad Base	109	Goedgedacht. 460	Town Lands	Kroonstad	Kroonstad, 1 m. S.	Water from river. Beacon on E. side of Valsch River on slight rise on right hand of Lace Mine road.
Rietfontein	110	Rietfontein. 603	J. J. Wolmarans T. E. Labuschagne J. M. Odendal	Lindley	Lindley, 19 m. E.N.E.; Geduldfontein, 11 m. W.N.W.	Dam and spring at homestead. Beacon on highest point of high veld ridge 2 m. N. of S.W. beacon and ¼ m. E. of boundary of farm. Rietfontein.
Elandskop II	111	Sterkfontein. 281	P. P. Steyn	Lindley	Lindley, 20 m. S.S.W.; Driefontein, 5 m. W.N.W.	Water in spruit ¾ m. S.E. of point. Beacon on N. end of highest point of hill.
Kaffir Kop	112	Corner of Vraai-uitzicht Groenfontein, Klipfontein	Van der Merwe B. H. Pieters J. Van der Merwe	Lindley	Lindley, 16 m. N.W.	Water at homestead. Beacon on top of large boulder on top of kop.

Group VI.—Pretoria to Cape Colony—*continued.*

Name of Station.	Reference No.	Farm and No.	Name of Farm.	District.	Nearest Magistracy, R.O., T.O., &c.	Remarks.
Mijnhardts Rust ..	113	Mijnhardts Rust. 933	W. C. Mijnhardt J. D. Cronje	Winburg	Senekal, 18 m. S.S.E.; Landplaats, 7 m. W.	Dam at farmhouse ¾ m. W. of point. Beacon on highest point of grass ridge, 250 yds. S. of boundary fence between M. H. Rust and Springhaan's Kop and ½ m. from boundary of Wonderfontein.
Zwartkrans	114	Bamboeskloof. 335..	P. J. Slabbert ..	Ficksburg	Fouriesburg, 13½ m. S.E.; P.O. Kaffirskop, 8 m. N.E.	Springs all round base of mountain. Beacon is on top of high blunted peak rising above Wittebergen, near the junction of farms Pietersdal, Rietvlei, Bothasberg, Weltevreden, and Bamboeskloof.
Rhebokberg	115	Lovedale. 292 ..	Mary E. Thompson	Ladybrand ..	Ladybrand, 23 m. S.; P.O. Clocolan, 7 m. S.E.	Water in dam on farm Belmont 850 ft. below point. Beacon on high massive clump of rocks rising abruptly from flat top of mountain on boundary of Morgenrood and Lovedale, 300 yds. S. of boundary of Belmont.
Machache	116	Ward of	Chief Theko ..	Border of Maseru and Berea	Maseru, 30 m. W.	Water in springs 800 ft. below summit on E. face. Beacon on highest point of conspicuous high mountain at N. end of Maluti range.
Mabula	117	Klipnek. 92.. ..	G. S Pretorius ..	Ladybrand ..	Ladybrand, 15 m. N.E.; P.O. Commissie Poort, 2 m. N.E	Water in kloof on E. face 350 ft. below summit. Beacon is on highest point of rocky bluff rising sharply from high veld.
Thaba Putsua.. ..	118	Ward of	Part. Chief Letsie..	Maseru	Maseru, 37 m. N.W.; Store at Mokeme near Clopho	Water at foot of S. slopes 1,100 ft. below summit. Beacon is on centre of three highest ridges. Guide Moledi at Mene's Kraal.
Thaba Tsueu	119	Ward of	Chief Seiso ..	Mafeteng	Mafeteng, 12 m. W. ..	Water in spring 400 ft. below beacon, also near Mr. Boning's store. Beacon on highest point at S. end of conspicuous wedge-shaped ridge.

GROUP VI.—PRETORIA TO CAPE COLONY—*continued.*

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Jammersberg	120	Town Lands. 178 . .	Municipality . .	Wepener	Wepener 2 m. S.E.	Water at dam S. of hill. Beacon on highest point on W. end of high ridge 2 m. N.W. of Wepener.
Dikhoele	121	Ward of	Part. Chief Letsie	Mafeteng	Mafeteng 4 m. W.N.W. . .	Water in spring in centre of plateau, ½ m. N. of, and 225 ft. below beacon. Beacon on high point at S.W. end of plateau, close to and eastwards of Mafeteng.
North End, Wepener Base	122	Waterford. 99 . .	. .	Wepener	Wepener 2 m. E.	Beacon on knoll, 1½ m. S. of Jammersberg Drift. Water in Caledon River.
South End, Wepener Base	123	Workshop. 97 . .	. .	Wepener	Wepener 13 m. N.	Water on Pitcairn, 1 m. north. Beacon on high rise forming watershed of several spruits S. of Wepener.
Gobo Gobo	124	Dorcum. 22 . .	A. J. Smith . .	Wepener	Wepener 17 m. N.; P.O. Bushman's Kop 5 m. E.S.E.	Water at farmhouse. Beacon on highest point of hill in S.W. corner of farm.
Aasvogelberg	127	Town lands	Municipality . .	Rouxville	Zastron, 2 m. S.E.	Water from town dam, or spring on western side of summit. Beacon on very highest point, on enormous boulder at S. end of hill.
Nthodimonate . . .	128	Ward of	Stock Tyali, a Jambookie headman who is under Chief Simpe.	Quthing	Moyeni 10 m. N.; Store at Komo Komong.	Water in spring E. of point and 675 ft below. Beacon on top of pointed peak on spur running down from Drakensberg, W. of source of Komo Komong River. Ascent starts at Kaffir Kraal.
Helvelyn	129	Corner of Helvellyn and Town Commonage,	G. F. Stephenson and D. R. Church	Aliwal North F. C. New England.	Lady Grey 4 m. W.	Spring near point on slope to S.E. Beacon is E. of town 110° from small dam, and on right hand corner of higher portion of ridge. Site of old district beacon and corner of commonage.

GROUP VI.—PRETORIA TO CAPE COLONY—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Bendearg	130	Bendearg	J. J. H. van Jaarsveld.	Barkly East. F. C. No. 5 Drakensberg.	Barkly East 23 m. N.W.; Elliott 16 m. S.W.; P.O. and Store on Barkly Pass.	Water in weak springs S. and W. of summit, abundance in kloof S.W. running up from Glenorchy (Jordaan). Beacon on western of double peak above the source of Sterkspruit, in the bend of the Quathlamba Mountains, and on the border between Barkly East and Maclear districts (Griqualand East).
Waschbank Peak ..	131	Bamboesfontein ..	F. F. Fourie & Co.	Wodehouse. F.C. East Waschbank.	Indwe 16 m. S.; P.O. Wolvehoek *via* Dordrecht.	Water in strong streams on farms below, and springs near top on S.E. slope. Beacon on very high and conspicuous peak at western end of the Quathlamba range about 5 m. N. of Xalanga Peak.
Xuka	10	Corner of Noah's Ark and Cormor Commonages.	Cape Government..	Elliott (Tembuland)	Elliott 9 m. W.	Water in spring on S.E. slope, and below in stream on S.E. Beacon on wooded peak on southern spurs of the Drakensberg 8 m. to S.S.W. of the well-known and conspicuous Gatberg, E.N.E. of Elliott. Former names Pangela Kop and Mount Ararat.
Lubisi	8	Unsurveyed land ..	Cape Government..	St. Marks (Tembuland).	St. Marks 14 m. S.S.W.; Lady Frere 16 m. W.N.W.; P.O. Southeyville 2 m. S.	Water plentiful in springs, near top on S.E. side. Beacon on highest point of southern bluff of Lubisi range, about 2 m. N., and overlooking Southeyville.
Cweoweni	9	Unsurveyed land ..	Cape Government..	St. Marks and Engcobo.	Engcobo 13½ m. N.; P.O. The Main or Marriott's store.	Strong running streams at foot of hill, several weak springs near summit. Beacon is on top of highest knoll in middle of low range of hills forming the watershed between the Quitsi and Owecweni Rivers, about 2 m. E. of Oldham's farm. On N. end of range as viewed from W.

DESCRIPTIVE LIST OF TRIGONOMETRICAL STATIONS—*continued.*

GROUP VII.—KIMBERLEY TO NEWCASTLE.

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Rererence No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks
Scholtz Kop	149	Mauretzfontein. K 50	Bissett	Kimberley C.C.	Kimberley, 12 m. N.N.E.; Spijtfontein Station, 1½ m. N.W.	Water near Spijtfontein station. Beacon on highest point of kop near railway line.
Paardeberg	163	Paardeberg. 124	Lands Settlements	Jacobsdal	Kimberley, 24 m. N.W.; Jacobsdal, 18 m. W.S.W.	Water in Modder river. Beacon on eastern or highest of three rises on Paardekop just N. of drift over river.
Rondefontein	164	Rondefontein. 511 Kleinfontein. 503	Jacobs	Boshof	Boshof, 20 m. N.W.	Water at Van Wyks farm, Kanonfontein. Beacon on highest point of kop, locally known as Rondekop.
Kareelaagte	168	Kareelaagte. 12	Jacobs	Boshof	Boshof, 18 m. W.	Water in dam at house. Beacon highest point 400 yds. S. from farm beacon and 100 yds. from fence.
Du Plessis Dam	169	Du Plessis Dam. 204	Owner: du Plessis Occupier: Smith	Boshof	Boshof, 20 m. S.W.	Water at homestead. Beacon on highest point of small kop N. of main road from Boshof to Hoopstad.
Bosberg	170	Doornpoort. 336 (sub-div. Bosberg)	Laurentz	Brandfort	Brandfort, 25 m. E.S.E.; Bultfontein, 13 m. N.N.E.	Water in kloof E. of house and in dams. Beacon on top of conspicuous wooded kop just E. of homestead.
Weltevreden	171	Weltevreden. 107	Mrs. M. E. O. Vivier	Hoopstad	Hoopstad, 32 m. N.; Bultfontein, 21 m. E.S.E.	Water in spring N. of homestead. Beacon on low rocky ridge 1,000 yds. N.E. of homestead, and 550 yds. from farm beacon (a tree) common to Blesbokfontein, Weltevreden and Strijdfontein.

GROUP VII.—KIMBERLEY TO NEWCASTLE.—*continued.*

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Biesie Pan	172	Biesie Pan. 110	Schoeman	Brandfort	Bultfontein, 5 m. S.S.E.	Water at homestead. Beacon on horse-shoe shaped hill at N.E. corner of ridge, and 1 m. N.W. of farmhouse.
Schoongezicht	173	Schoongezicht. 237	Le Roux	Brandfort	Brandfort, 25 m. S.; Bultfontein, 14 m. W.	Water in dam at homestead. Beacon on highest point of bult 300 yds. from farm.
Therons Kop	174	Wynandsfontein. 653	Theron	Winburg	Smaldeel, 6½ m. S.E.	Water by railway. Beacon in sangar on highest point in centre of kop.
Zoetvlei	175	Zoetvlei 111	W. Magnus	Hoopstad	Hoopstad, 25 m. W	Water at pans or at homestead. Beacon is on slight rise about 1 m. N. of road from Zoetvlei to Klipheuvel.
Nooitverwacht	176	Nooitverwacht. 248	Van Wyk	Bothaville	Bothaville, 5 m. N.	Water at farm Hartebeest bult (van Zyl). Beacon on top of bult close to farm beacon Nooitverwacht, Doornkraal and Hartebeest bult.
Langberg II.	177	Rhebokpoort. 715	A. S. Human	Bethlehem	Bethlehem, 12 m. W.; P.O., Uitdraaipad, 4 m. S.E.	Water in kloof leading up from Bellevue. Beacon on highest point of solid stone summit.
Vierfontein	178	Vierfontein. 252	du Plessis	Reitz	Reitz, 12 m. S.W.	Water in dam near homestead. Beacon 6 yds. E. of corner of fences, and in line with fence running W. along ridge. Highest point of ridge running N.W. to S.E.
Vaalbank Kop	179	Patryshoek. 218	C. Villiers	Harrismith	Harrismith, 40 m. S.; store at Cornelius River Bridge, 6 m. N.W.	Water at farm to N. Beacon 6 yds. N.E. of fences dividing Welgevonden, Patryshoek, and Vaalbank Kop.
Kaalkop	180	Corner of Kaalkop. 191 Strydpoort. 189	A. B. Van Niekerk Odendaal	Vrede	Vrede, 15 m. N.	Water at Rietkuil homestead. Beacon on top of hill 16 ft. from corner along fence, and 10 ft. N. at right angles.

Descriptive List of Trigonometrical Stations—*continued.*

Group VII.—Kimberley to Newcastle—*continued.*

[Bracketed numbers are the numbers cut on the beacon.]

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Hermitage (Witkoppies)	181	Corner of Boschfontein. 285 Hermitage. 60 Boschoek. 286	Conradie	Vrede	Vrede, 30 m. N.N.W. ..	Water at farm or in kloof to W. Beacon is on highest point of mountain at S.E. end.
Gemsbokberg.. ..	182	Gemsbokberg. 268 ..	Martin Uys ..	Vrede	Vrede, 18 m. W.	Water in kloof ¾ m. S. of beacon. Beacon on N.W. high point bears 285° from E. point, and is 1,020 yds. from fence on this line.
Drakensberg	58	Vlakplaats. 726 ..	D. Neumann ..	Newcastle.. ..	Newcastle, 30 m. E.N.E.; P.O., Mullers pass, 10 ms.	Water in spring N.W. of point in small kloof. Beacon bears 115° from highest point, on W. angle of hill, 330 yds. distant.

Group VIII.—Hope Town to Wepener.

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Besters Kop	133	Besterskop	Strauss Bester ..	Phillipstown C.C.. .	Petrusville, 25 m. E.; Paauwpan Station, 6 m. W.	Water at homestead. Beacon on top of, easily recognizable, Spitzkop.
Orange River	134	Elandsdraai	Naude	Phillipstown, C.C.	Hope Town, 25 m. W.; Orange River Station, 8 m. W.	Water in dam towards homestead. Beacon on highest point of stony kop, ½ m. N. of road from Orange River Station to Elandsdraai.
Wonderkloof	135	Wonderkloof ..	Van der Walt ..	Phillipstown, C.C.	Petrusville, 10 m. S.W. ..	Water in well and dam at homestead. Beacon on highest point of Northern summit.

Group VIII.—Hope Town to Wepener—*continued*.

Name of Station.	Reference No.	Farm and No.	Owner of Farm.	District.	Nearest Magistracy, P.O., T.O., &c.	Remarks.
Boschjespan	136	Boschjespan, portion of Van der Bergs Kraal. 105	Lombaard	Jacobsdal	Luckhoff, 17 m., S.E.	Water at farmhouse 3 m. S. of point. Beacon on top of a prominent spitzkop.
Platkop	137	Vaalhoek. 495	Van Rensburg	Fauresmith	Fauresmith, 18 m. S.E.; Koffyfontein, 14 m. N.N.W.	Water in well and dam at homestead. Beacon on small rise on Western edge of conspicuous flat topped kopje.
Fauresmith Hill	138	Town Lands	Town	Fauresmith	Fauresmith, 1¼ m. W.	Water near drift on Jagersfontein Road. Beacon at N.E corner near East face of top prominent tafel kop called Kranzkop locally.
Lokshoek	139	Lokshoek. 132	Visser Bros.	Fauresmith	Fauresmith, 16 m. W.S.W.; Jagersfontein, 12 m. S.W.	Water at farmhouse. Beacon on Western edge near middle of kop, which is a prominent flat-topped spitz.
Luiper's Rand	140	Luiper's Rand. 530	E. S. Terblanche	Fauresmith	Fauresmith, 16 m. N.E.	Water at farmhouse at Hebron, 2 m. N. Beacon on northern summit of a small group of hills S.W. of Fauresmith.
Driebaden	141	Driebaden. 493	Douglas	Fauresmith on border of Phillipolis	Fauresmith or Jagersfontein, 20 m. N.; Phillipolis, 16 m. S.S.W.	Water in dam near unoccupied house. Beacon on highest point of hog-backed ridge.
De Put	142	De Puts. 100	Rensburg	Edenburg	Edenburg; Trompsburg, 16 m. N.W	Water in dam ½ m. E. of kop. Beacon on top of Spitz Kop with white Kranzes near top.
Lemoenfontein	125	Lemoenfontein. 367	P. Venter	Smithfield, near boundary of Bloemfontein	De Wetsdorp, 15 m. E.N.E.; Reddersburg, 15 m. W. N.W.	Water at Farm. Beacon on summit of northern end of line of hills running approximately N. and S., forming border between Bloemfontein and Smithfield Districts.
Koesberg	126	Kalkhoek. 272	P. Swanepoel	Rouxville	Zastron, 8 m. E.	Water in kloof E.S.E. of beacon. The hill is a large and prominent one running N. and S and W. of Zastron The beacon is on a large rock 20 feet high on W. of kop.

FINAL RESULTS.

LATITUDE, LONGITUDE, AZIMUTH, LOG LENGTHS OF LINES, AND HEIGHTS ABOVE MEAN SEA LEVEL.

BREAKFAST VLEI.

Station No. 1.

	° ′ ″
Latitude	33 5 29·318.
Longitude	26 57 8·685.
Height above M.S.L.	1747·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Hogsback..	2	187 1 46·68	5·2604874
Bekruip Kop	3	257 53 3·48	5·2194396

HOGSBACK.

Station No. 2.

	° ′ ″
Latitude	32 35 40·263.
Longitude	27 1 29·264.
Height above M.S.L.	6360·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Breakfast Vlei	1	6 59 25·36	5·2604874
Windvogel Berg..	6	194 30 15·08	5·0475343
Gonubie	4	272 28 22·16	5·3335518
Berlin	5	300 52 59·38	5·3246529
Bekruip Kop	3	316 12 52·76	5·3056105

BEKRUIP KOP.

Station No. 3.

	° ′ ″
Latitude	32 59 41·088.
Longitude	27 28 51·240.
Height above M.S.L.	1590·0 feet.

Station Observed.	Station No	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Breakfast Vlei	1	77 35 46·07	5·2194396
Hogsback..	2	135 58 3·41	5·3056105
Gonubie	4	208 40 40·96	5·1988646
Berlin	5	227 33 7·58	4·7470787

Final Results—*continued.*

GONUBIE.

Station No. 4.

	° ′ ″
Latitude	32 37 5·280.
Longitude	27 43 26·928.
Height above M.S.L.	2795·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Berlin	5	18 37 5·12	5·0203689
Bekruip Kop	3	28 32 46·51	5·1933646
Hogsback	2	92 5 45·47	5·3335518

BERLIN.

Station No. 5.

	° ′ ″
Latitude	32 53 27·821.
Longitude	27 36 54·571.
Height above M.S.L.	1699·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Bekruip Kop	3	47 28 44·74	4·7470787
Hogsback	2	120 33 49·86	5·3246529
Gonubie	4	198 40 37·40	5·0203689

WINDVOGELBERG.

Station No. 6.

	° ′ ″
Latitude	32 17 51·360.
Longitude	27 6 54·774.
Height above M.S.L.	5357·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Hogsback	2	14 27 20·44	5·0475343
Lubisi	8	211 48 21·51	5·3490401
Mbulu	7	253 25 10·39	5·2801574
Gonubie	4	301 59 48·94	5·3445819

FINAL RESULTS—*continued.*

MBULU.

Station No. 7.

	° ′ ″
Latitude	32 8 48·135.
Longitude	27 42 19·521.
Height above M.S.L.	3901·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Windvogelberg	6	78 6 17·46	5·2801574
Lubisi	8	154 3 48·09	5·1767018
Owecweni	9	225 6 1·64	5·1486140
Gonubie	4	358 4 28·42	5·2345385

LUBISI.

Station No. 8.

	° ′ ″
Latitude	31 46 30·743.
Longitude	27 29 38·497.
Height above M.S.L.	5823·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Windvogelberg	6	31 36 18·10	5·3490401
Waschbank Peak	181	176 2 32·65	5·2767092
Xuka	10	222 8 46·52	5·3688495
Owecweni	9	282 17 10·28	5·2285083
Mbulu	7	334 10 30·94	5·1767018

OWECWENI.

Station No. 9.

	° ′ ″
Latitude	31 52 23·132.
Longitude	28 1 36·061.
Height above M.S.L.	4198·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Mbulu	7	44 55 48·60	5·1486140
Lubisi	8	102 0 19·18	5·2285083
Xuka	10	177 20 59·74	5·3208538
Bazeia	11	223 31 9·38	5·2089910

FINAL RESULTS—*continued.*

XUKA.

Station No. 10.

	° ′ ″
Latitude	31 17 53·589.
Longitude	27 59 44·512.
Height above M.S.L.	6212·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Lubisi	8	41 53 1·89	5·3683495
Waschbank Peak	131	94 57 27·77	5·2816811
Bendearg	130	175 57 23·85	4·8360795
View Hill	12	247 37 5·39	5·2052291
Bazeia	11	307 10 32·92	5·1816999
Cwecweni	9	357 21 58·16	5·3208538

BAZEIA.

Station No. 11.

	° ′ ″
Latitude	31 33 0·171.
Longitude	28 23 3·576.
Height above M.S.L.	5501·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Cwecweni	9	43 19 52·60	5·2089910
Xuka	10	126 58 23·49	5·1816099
View Hill	12	189 54 17·32	5·1911900
Bele	14	227 0 42·50	5·0850826
Ncolora	13	244 2 59·64	5·1805408
Nquadu	15	249 3 13·38	5·1182671

VIEW HILL.

Station No. 12.

	° ′ ″
Latitude	31 7 45·923.
Longitude	28 28 10·908.
Height above M.S.L.	5137·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bazeia	11	9 51 37·47	5·1911900
Xuka	10	67 22 21·08	5·2052291
Ladykok	19	216 26 45·01	5·2116766
Nquashu	18	274 20 22·16	5·1814876
Ncolora	13	308 18 22·92	5·1451741
Bele	14	318 19 21·17	4·9718468

FINAL RESULTS—*continued.*

NCOLORA.

Station No. 13.

	° ′ ″
Latitude	31 22 1·194.
Longitude	28 49 15·160.
Height above M.S.L.	3797·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Nquadu	15	36 50 44·40	4·3971950
Bazeia	11	68 49 19·46	5·1805408
Bele	14	109 8 43·61	4·7000367
View Hill	12	128 7 27·09	5·1451741
Ladykok	19	176 25 31·18	5·3883332
Nquashu	18	208 55 52·92	4·9842882

BELE.

Station No. 14.

	° ′ ″
Latitude	31 19 18·180.
Longitude	28 40 9·315.
Height above M.S.L.	4853·9 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Gcwengana	16	7 18 43·67	4·8007082
Bazeia	11	46 51 47·58	5·0850826
View Hill	12	138 13 8·74	4·9718463
Nquashu	18	236 36 39·61	5·0277990
Ncolora	13	289 13 27·55	4·7000367
Nquadu	15	318 25 41·14	4·6877874
Umtata	17	346 57 32·16	5·0108100

NQUADU.

Station No. 15.

	° ′ ″
Latitude	31 25 18·822.
Longitude	28 46 22·455.
Height above M.S.L.	4279·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Umtata	17	8 12 2·35	4·8067550
Gcwengana	16	56 56 18·38	4·6825920
Bazeia	11	68 51 2·76	5·1132671
Bele	14	138 22 26·89	4·6877874
Ncolora	13	216 52 14·37	4·3971950

Final Results —*continued.*

GCWENGANA.

Station No. 16.

		° ′ ″
Latitude	... ...	31 29 38·549.
Longitude	... ...	28 38 36·421.
Height above M.S.L.	... ...	2661·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bele	14	187 19 32·08	4·8007082
Nquadu	15	237 0 21·54	4·6825920
Umtata	17	320 2 26·88	4·6860157

UMTATA.

Station No. 17.

		° ′ ″
Latitude	... ...	31 35 46·549.
Longitude	... ...	28 44 36·772.
Height above M.S.L.	... ...	2847·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Gowengana	16	139 59 18·36	4·6860157
Bele	14	166 55 12·58	5·0108100
Nquadu	15	188 12 57·58	4·8067550

NQUASHU.

Station No. 18.

		° ′ ″
Latitude	... ...	31 9 36·385.
Longitude	... ...	28 57 13·706.
Height above M.S.L.	... ..	4084·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Ncolora	13	28 51 44·57	4·9842882
Bele	14	56 27 48·82	5·0277990
Viewhill	12	94 5 20·78	5·1814876
Ladykok	19	158 44 14·19	5·1885696
Insizwa	20	210 50 57·05	5·1890302

FINAL RESULTS—*continued.*

LADYKOK.

Station No. 19.

	° ′ ″
Latitude	30 46 8·359.
Longitude	28 46 39·422.
Height above M.S.L.	6612·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Viewhill	12	36 17 14·92	5·2116766
Jumbla	21	198 14 40·02	5·0114485
Insizwa	20	274 8 47·78	5·1300817
Nquashu	18	338 49 40·54	5·1835696
Ncolora	13	356 26 51·55	5·3383332

INSIZWA.

Station No. 20.

	° ′ ″
Latitude	30 47 42·373.
Longitude	29 12 22·176.
Height above M.S.L.	6128·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Nquashu	18	30 43 9·45	5·1890302
Ladykok	19	93 55 33·23	5·1300817
Jumbla	21	136 6 12·73	5·1711789
Mount Currie	22	209 48 24·05	5·1303010

JUMBLA.

Station No. 21.

	° ′ ″
Latitude	30 30 3·062.
Longitude	28 52 46·813.
Height above M.S.L.	7517·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Ladykok	19	18 11 32·81	5·0114485
Mungunung	23	185 5 25·64	4·9139397
Zwartberg	24	230 53 13·95	5·3384636
Mount Currie	22	266 42 40·59	5·2310678
Insizwa	20	316 16 11·80	5·1711789

FINAL RESULTS—*continued.*

MOUNT CURRIE.

Station No. 22.

	° ′ ″
Latitude	30 28 22·373.
Longitude	29 25 8·891.
Height above M.S.L.	7296·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Insizwa	20	29 41 53·37	5·1303010
Jumbla	21	86 26 15·29	5·2310678
Mungunung	23	113 34 48·57	5·2501217
Zwartberg	24	179 21 47·55	5·1064022
Malowe	25	247 7 18·60	5·1898561
Hluku	26	283 50 59·73	5·2386831
Ingeli	27	314 54 20·79	4·8708177
Kokstad	28	355 17 48·85	4·4578099

MUNGUNUNG.

Station No. 23.

	° ′ ″
Latitude	30 16 34·354.
Longitude	28 54 9·807.
Height above M.S.L.	6539·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Jumbla	21	5 4 43·65	4·9139307
Zwartberg	24	250 57 33·31	5·2335762
Mount Currie	22	293 50 28·63	5·2501217

ZWARTBERG.

Station No. 24.

	° ′ ″
Latitude	30 7 17·793.
Longitude	29 24 52·723.
Height above M.S.L.	7615·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Jumbla	21	50 37 1·94	5·3384636
Mungunung	23	70 42 6·30	5·2335762
Marwaga	31	222 21 12·20	5·1937946
Mabehlan	30	262 31 55·83	5·2116348
Malowe	25	295 7 31·37	5·2017855
Mount Currie	22	359 21 55·71	5·1064022

FINAL RESULTS—*continued.*

MALOWE.

Station No. 25.

	° ′ ″
Latitude	30 18 23·731.
Longitude...	29 52 16·129.
Height above M.S.L.	4888·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Ingeli	27	38 24 52·04	5·1589552
Mount Currie	22	66 58 35·41	5.1898561
Zwartberg	24	114 58 44·35	5·2017355
Mabehlan	30	190 49 54·79	4·9561719
Hluku	26	345 39 18·75	5·0204925

HLUKU.

Station No. 26.

	° ′ ″
Latitude	30 35 8·941.
Longitude...	29 57 13·249.
Height above M.S.L.	3309·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Ingeli	27	84 18 51·25	5·0649485
Mount Currie	22	103 34 42·19	5·2386831
Malowe	25	165 36 48·19	5·0204925
Umtamvuna	29	358 36 18·76	4·7429561

INGELI.

Station No. 27.

	° ′ ″
Latitude	30 37 0·956.
Longitude...	29 35 10·853.
Height above M.S.L.	7442·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kokstad	28	115 17 18·26	4·7451987
Mount Currie	22	134 49 14·86	4·8708177
Malowe	25	218 38 31·82	5·1589552
Hluku	26	264 30 4·43	5·0649485
Umtamvuna	29	290 48 45·52	5·0968704

FINAL RESULTS—*continued.*

KOKSTAD.

Station No. 28.

	° ′ ″
Latitude	30 33 5·447.
Longitude...	29 25 35·796.
Height above M.S.L.	4268·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Mount Currie	22	175 17 35·19	4·4578099
Ingeli	27	295 22 10·35	4·7451987

UMTAMVUNA.

Station No. 29.

	° ′ ″
Latitude	30 44 16·427.
Longitude...	29 57 28·680.
Height above M.S.L.	2602·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Ingeli	27	110 32 22·95	5·0963704
Hluku	26	178 36 10·89	4·7429561

MABEHLAN

Station No. 30.

	° ′ ″
Latitude	30 3 44·785.
Longitude	29 55 29·446.
Height above M.S.L.	4895·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Malowe	25	10 48 17·59	4·9561719
Zwartberg	24	32 16 34·91	5·2116348
Marwaqa	31	148 58 25·22	5·0404251
Byrne Town	32	219 58 19·25	5·1147785

FINAL RESULTS—*continued.*

MARWAQA.

Station No. 31.

	° ′ ″
Latitude	29 48 13·315.
Longitude	29 44 47·382.
Height above M.S.L.	6832·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Zwartberg	24	42 11 15·54	5·1987946
Spioen Kop (Natal)	35	187 18 9·74	5·1154220
Inhluzan	33	214 39 40·56	5·0629723
Zwart Kop I.	34	244 36 20·34	5·2515677
Byrne Town	32	267 44 3·48	5·1472551
Mabehlan	30	329 3 45·60	5·0404251

BYRNE TOWN.

Station No. 32.

	° ′ ″
Latitude	29 47 15·721.
Longitude	30 11 18·970.
Height above M.S.L.	5165·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Mabehlan	30	39 50 25·56	5·1147785
Marwaqa	31	87 30 52·60	5·1472551
Inhluzan	33	140 0 57·16	5·0662636
Zwart Kop I.	34	196 14 24·69	4·8693508

INHLUZAN.

Station No. 33.

	° ′ ″
Latitude	29 32 31·416.
Longitude	29 57 11·653.
Height above M.S.L.	6482·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Marwaqa	31	34 33 32·11	5·0629723
Spioen Kop (Natal)	35	124 47 50·45	4·7777685
Arrochar	37	201 57 42·33	5·1061585
Mount Gilboa	36	229 30 16·13	5·1544606
Zwart Kop I.	34	280 53 31·77	4·9879571
Byrne Town	32	320 7 56·52	5·0662636

FINAL RESULTS—*continued.*

ZWART KOP I.

Station No. 34.

	° ′ ″
Latitude	29 35 32·141.
Longitude	30 15 13·426.
Height above M.S.L.	4758·0* feet. 4756·4 „

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Byrne Town	32	16 12 28·57	4·8698508
Marwaqa	31	64 21 15·66	5·2515677
Inhluzan	33	100 44 37·98	4·9879571
Spioen Kop (Natal)	35	109 49 11·25	5·1875126
Arrochar	37	160 36 29·12	5·1610682
Mount Gilboa	36	186 32 8·42	5·0484974
Morton's Hill	40	194 44 33·58	4·8610795
Green Kop	38	216 34 7·02	5·0913868
Baynes' Hill	39	240 30 44·70	4·9929747

* By actual levelling.

SPIOEN KOP (NATAL.

Station No. 35.

	° ′ ″
Latitude	29 26 52·422.
Longitude	29 47 54·908.
Height above M.S.L.	7037·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Marwaqa	31	7 16 37·04	5·1154220
Table Mountain	51	157 45 49·15	5·1129083
Arrochar	37	229 6 22·13	5·1087076
Zwartkop I.	34	290 2 38·60	5·1875126
Inhluzan	32	304 52 24·56	4·7777685

MOUNT GILBOA.

Station No. 36.

	° ′ ″
Latitude	29 17 12·370.
Longitude	30 17 37·138.
Height above M.S.L.	5796·3 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Zwartkop I.	34	6 30 57·78	5·0484974
Inhluzan	33	49 20 14·27	5·1544605
Arrochar	37	112 47 43·19	4·8195511
Greenkop	38	281 7 21·70	4·7921424
Baynes' Hill	39	310 38 55·73	4·9829104
Morton's Hill	40	351 57 47·45	4·6155070

FINAL RESULTS—*continued.*

ARROCHAR.

Station No. 37.

	° ′ ″
Latitude	29 12 58·719.
Longitude	30 6 10·531.
Height above M.S.L.	5686·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Inhluzan	33	21 53 17·97	5·1061585
Spioen Kop (Natal)	35	48 57 25·42	5·1087076
Table Mountain	51	103 40 20·47	5·1776191
Umkolumbu	52	186 38 26·76	5·0656295
Mount Gilboa	36	292 53 18·70	4·8195511
Zwartkop I.	34	340 40 55·66	5·1610682

GREENKOP.

Station No. 38.

	° ′ ″
Latitude	29 19 10·220.
Longitude	30 29 3·921.
Height above M.S.L.	3271·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Zwartkop I.	34	36 27 18·62	5·0913868
Morton's Hill	40	62 12 4·56	4·7935018
Mount Gilboa	36	101 1 45·56	4·7921424
Baynes' Hill	39	346 25 49·52	4·7169174

BAYNES' HILL.

Station No. 39.

	° ′ ″
Latitude	29 27 31·680.
Longitude	30 31 22·213.
Height above M.S.L.	2862·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in Englise Feet.
		° ′ ″	
Zwartkop I.	34	60 22 47·27	4·9929747
Otto's Bluff	41	74 38 29·62	4·7258899
Morton's Hill	40	107 50 53·73	4·8489098
Mount Gilboa	36	130 32 11·04	4·9829104
York..	42	147 36 29·02	4·5958134
Greenkop	38	166 24 41·65	4·7169174

FINAL RESULTS—*continued.*

MORTON'S HILL.

Station No. 40

	° ′ ″
Latitude	29 23 56·806.
Longitude	30 18 42·345.
Height above M.S.L.	4038·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Zwartkop I.	34	14 42 50·67	4·8610795
Mount Gilboa	36	171 57 15·50	4·6155070
Greenkop	38	242 17 9·31	4·7935018
York	42	255 55 13·18	4·6771086
Baynes' Hill	39	287 57 7·09	4·8489098
Otto's Bluff	41	336 1 1·95	4·5933468

OTTO'S BLUFF.

Station No. 41.

	° ′ ″
Latitude	29 29 51·391.
Longitude	30 21 42·662.
Height above M.S.L.	3119·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Morton's Hill	40	155 59 33·30	4·5933468
Morton's Kraals	44	168 58 35·61	4·4993868
York	42	212 28 8·50	4·7496007
Baynes' Hill	39	254 38 14·82	4·7253899
Baynes	43	264 29 19·57	4·4657939

YORK.

Station No. 42.

	° ′ ″
Latitude	29 22 2·016.
Longitude	30 27 23·511.
Height above M.S.L.	2692·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Baynes	43	1 19 34·52	4·6493918
Otto's Bluff	41	32 25 21·01	4·7496007
Morton's Kraals	44	65 35 23·57	4·5997476
Morton's Hill	40	75 50 57·46	4·6771086
Baynes' Hill	39	327 38 26·25	4·5958134

Final Results—*continued.*

BAYNES.

Station No. 43.

	° ′ ″
Latitude … … … …	29 29 23·489.
Longitude … … … …	30 27 11·830.
Height above M.S.L. … …	2701·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Otto's Bluff	41	84 26 37·51	4·4657989
Kraals	46	99 16 15·20	4·2676536
Morton's Kraals	44	128 39 13·06	4·6539000
Mackenzie's	45	161 31 41·57	4·5054789
York	42	181 19 40·26	4·6498918

MORTON'S KRAALS.

Station No. 44.

	° ′ ″
Latitude … … … …	29 24 44·624.
Longitude … … … …	30 20 33·886.
Height above M.S.L. … …	2832·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
York	42	245 38 44·60	4·5997476
Mackenzie's	45	264 59 8·30	4·4005340
Baynes	43	308 42 28·72	4·6539000
Kraals	46	326 8 37·40	4·4818237
Otto's Bluff	41	348 54 9·43	4·4998868

MACKENZIE'S.

Station No. 45.

	° ′ ″
Latitude … … … …	29 24 22·778.
Longitude … … … …	30 25 17·123.
Height above M.S.L. … …	2507·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kraals	46	16 33 7·06	4·4559418
Round Hill	48	51 13 51·83	4·1929449
Morton's Kraals	44	84 56 49·22	4·4005340
Baynes	43	341 32 37·96	4·5054789
Waterfall	47	352 18 4·24	4·1284930

Final Results—*continued.*

KRAALS.

Station No. 46.

	° ′ ″
Latitude	29 28 53·906.
Longitude	30 23 45·033.
Height above M.S.L.	2415·8 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Morton's Kraals	44	146 7 8·43	4·4818237
Round Hill	48	167 10 7·28	4·2571012
Mackenzie's	45	196 33 52·33	4·4559413
Waterfall	47	215 15 40·60	4·2361427
Baynes	43	279 17 56·99	4·2676536

WATERFALL.

Station No. 47.

	° ′ ″
Latitude	29 26 34·660.
Longitude	30 25 37·490.
Height above M.S.L.	2195·8 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kraals	46	35 14 45·29	4·2361427
South end of Base	49	74 38 38·49	3·9013774
Round Hill	48	104 17 39·95	4·1585127
North end of Base	50	157 25 36·91	3·9222105
Mackenzie's	45	172 17 54·23	4·1284930

ROUND HILL.

Station No. 48.

	° ′ ″
Latitude	29 25 59·424.
Longitude	30 22 59·638.
Height above M.S.L.	2382·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Mackenzie's	45	231 14 59·36	4·1929449
North end of Base	50	248 51 8·42	4·0617466
Waterfall	47	284 18 57·53	4·1585127
South end of Base	49	312 6 22·85	3·9271175
Kraals	46	347 10 29·60	4·2571012

FINAL RESULTS—*continued.*

SOUTH END OF BASE.

Station No. 49.

		° ′ ″
Latitude	... ...	29 26 55·543.
Longitude	... ...	30 24 10·584.
Height above M.S.L.	... ...	2088·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Round Hill	48	132 5 47·98	3·9271175
North end of Base	50	204 29 19·63	4·0334423
Waterfall	47	254 39 21·21	3·9013774

NORTH END OF BASE.

Station No. 50.

		° ′ ″
Latitude	... ...	29 25 18·236.
Longitude	... ...	30 25 1·204.
Height above M.S.L.	... ...	2084·9* feet. 2081·8 ,,

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
South end of Base	49	24 28 54·75	4·0334423
Round Hill	48	68 50 8·69	4·0617466
Waterfall	47	337 25 54·74	3·9222105

* By actual levelling.

TABLE MOUNTAIN.

Station No. 51.

		° ′ ″
Latitude	... ...	29 7 3·643.
Longitude	... ...	29 38 41·620.
Height above M.S.L.	... ...	6508·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Onderbrook	53	194 27 24·23	5·2438827
Umkolumbu	52	243 37 48·83	5·2519006
Arrochar	37	283 53 44·08	5·1776191
Spioen Kop (Natal)	35	337 50 19·78	5·1129083

FINAL RESULTS—*continued.*

UMKOLUMBU.

Station No. 52.

	° ′ ″
Latitude	28 53 54·872.
Longitude	30 8 41·850.
Height above M.S.L.	5005·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Arrochar	37	6 37 13·27	5·0656295
Table Mountain	51	63 23 15·84	5·2519006
Onderbrook	53	127 38 45·72	5·1681912
Jobskop	54	190 29 11·89	5·0725059

ONDERBROOK.

Station No. 53.

	° ′ ″
Latitude	28 39 2·370.
Longitude	29 46 52·897.
Height above M.S.L.	4289·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Table Mountain	51	14 23 26·92	5·2438827
Biggarsberg	55	206 3 33·33	5·2486334
Jobskop	54	259 25 22·52	5·1479983
Umkolumbu	52	307 49 15·80	5·1681912

JOBSKOP.

Station No. 54.

	° ′ ″
Latitude	28 34 44·369.
Longitude	30 12 43·069.
Height above M.S.L.	5690·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Umkolumbu	52	10 27 15·90	5·0725059
Onderbrook	53	79 13 0·11	5·1479983
Biggarsberg	55	155 27 44·01	5·1656800
Noma Hill	56	207 23 8·41	5·1614794

Final Results—*continued.*

BIGGARSBERG.

Station No. 55.

	° ′ ″
Latitude	28 12 44·823.
Longitude	30 1 23·300.
Height above M.S.L.	5861·8 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Onderbrook	53	25 56 38·92	5·2486334
Drakensberg	58	141 38 39·81	5·2338681
Salt Lake	57	186 49 49·78	5·0366166
Noma Hill	56	272 4 56·12	5·1058799
Jobskop	54	335 33 7·28	5·1656800

NOMA HILL.

Station No. 56.

	° ′ ″
Latitude	28 13 28·670.
Longitude	30 25 8·818.
Height above M.S.L.	5152·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Jobskop	54	27 17 13·69	5·1614794
Biggarsberg	55	91 53 42·08	5·1058799
Drakensberg	58	120 32 25·80	5·4346352
Salt Lake	57	134 19 41·57	5·2059958

SALT LAKE.

Station No. 57.

	° ′ ″
Latitude	27 54 55·153.
Longitude	30 3 47·529.
Height above M.S.L.	4616·3 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Biggarsberg	55	6 48 41·93	5·0366166
Drakensberg	58	102 26 6·47	5·0868519
Inkwelo	59	152 20 36·11	5·2109223
Nthabankulu	60	209 30 45·52	5·2486396
Noma Hill	56	314 29 44·48	5·2059958

FINAL RESULTS—*continued.*

DRAKENSBERG.

Station No. 58.

	° ′ ″
Latitude	27 50 32·942.
Longitude	29 41 38·950.
Height above M.S.L.	6682·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Hermitage	181	106 17 12·91	5·0714628
Gemsbokberg	182	148 21 15·41	5·2155723
Inkwelo	59	200 36 17·99	5·0988342
Newcastle..	58A	248 39 15·61	4·9126625
Salt Lake	57	282 36 27·72	5·0868519
Noma Hill	56	300 52 52·42	5·4346352
Biggarsberg	55	321 47 56·33	5·2338681

NEWCASTLE.

Station No. 58A.

	° ′ ″
Latitude	27 45 37·444.
Longitude...	29 55 46·798.
Height above M.S.L.	3908·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Drakensberg	58	68 32 40·17	4·9126625
Inkwelo	59	159 51 48·56	4·9703580

INKWELO.

Station No. 59.

	° ′ ″
Latitude	27 31 8·933.
Longitude...	29 49 49·684.
Height above M.S.L.	6808·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Drakensberg	58	20 32 30·02	5·0988342
Gemsbokberg	182	99 39 16·42	5·1214689
Langberg I	61	208 32 0·04	5·1288022
Hlamimpesi Berg..	62	240 38 55·91	5·3620723
Nthabankulu	60	266 28 54·04	5·2124321
Salt Lake	57	332 27 5·80	5·2109223
Newcastle	58A	339 54 34·23	4·9703580

FINAL RESULTS—*continued.*

NTHABANKULU.

Station No. 60.

	° ′ ″
Latitude ...	27 29 26·559.
Longitude...	30 19 57·141.
Height above M.S.L.	7463·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Saltlake	57	29 23 14·76	5·2486396
Inkwelo	59	86 14 59·81	5·2124321
Langberg I	61	137 26 30·54	5·1653012
Hlamimpesi Berg	62	199 58 44·77	5·0396616

LANGBERG I.

Station No. 61.

	° ′ ″
Latitude ...	27 11 38·049.
Longitude...	30 1 41·266.
Height above M.S.L.	6645·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Inkwelo	59	28 26 33·05	5·1288022
Blaauwkop	64	137 6 51·69	5·2303448
Elandsberg III	63	178 58 48·69	4·8514606
Hlamimpesi Berg	62	272 9 30·90	5·1850705
Nthabankulu	60	317 34 53·88	5·1653012

HLAMIMPESI BERG.

Station No. 62.

	° ′ ″
Latitude ..	27 12 26·697.
Longitude...	30 26 51·737.
Height above M.S.L.	7426·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Nthabankulu	60	19 55 34·30	5·0396616
Inkwelo	59	60 21 54·58	5·3620728
Langberg I	61	91 58 0·45	5·1850705
Elandsberg III	63	118 45 58·31	5·1967664
Spitzkop I	65	165 9 54·38	5·2350334

FINAL RESULTS—*continued.*

ELANDSBERG III.

Station No. 63.

	° ′ ″
Latitude	26 59 54·700.
Longitude...	30 1 27·291.
Height above M.S.L.	6286·3 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Blaauwkop	64	115 4 10·98	5·1018861
Tafel Kop (E.)	66	180 27 4·77	5·2604988
Spitzkop I..	65	226 17 31·49	5·1150617
Hlamimpesi Berg..	62	298 57 27·83	5·1967664
Langberg I	61	358 58 55·06	4·8514606

BLAAUWKOP.

Station No. 64.

	° ′ ″
Latitude	26 51 3·152.
Longitude	29 40 24·321.
Height above M.S.L.	5883·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Sterkfontein	67	207 42 4·48	5·3253033
Tafel Kop (E)	66	222 9 17·04	5·2883435
Elandsberg III.	63	295 13 42·88	5·1013861
Langberg I.	61	317 16 31·87	5·2303448

SPITZKOP I.

Station No. 65.

	° ′ ″
Latitude	26 45 1·724.
Longitude	30 18 46·535.
Height above M.S.L.	5991·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Elandsberg	63	46 9 41·72	5·1150617
Tafel Kop (E)	66	184 39 49·29	5·1164092
Vlakfontein	68	197 30 15·46	5·2955161
Hlamimpesi Berg..	62	345 13 34·50	5·2350334

FINAL RESULTS—*continued.*

TAFEL KOP (ERMELO).

Station No. 66.

		° ′ ″
Latitude	... ...	26 29 50·495.
Longitude	... ...	30 1 43·085.
Height above M.S.L.	... ...	6011·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Elandsberg III.	63	0 26 57·67	5·2604983
Blaauwkop	64	41 59 42·98	5·2383435
Sterkfontein	67	162 58 7·94	4·7893449
Baatjes Bult	69	205 11 55·27	5·1693937
Vlakfontein	68	237 48 2·70	5·2560711
Spitzkop I.	65	314 47 27·93	5·1164092

STERKFONTEIN.

Station No. 67.

		° ′ ″
Latitude	... ...	26 20 7·427.
Longitude	... ...	29 58 24·894.
Height above M.S.L.	... ...	6001·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Blaauwkop	64	27 34 0·75	5·3253033
Wonderfontein	72	171 53 44·05	5·2896535
Baatjes Bult	69	227 16 52·73	5·0421119
Tafel Kop (E)	66	342 59 36·11	4·7893449

VLAKFONTEIN.

Station No. 68.

		° ′ ″
Latitude	... ...	26 13 56·035.
Longitude	... ...	30 29 38·769.
Height above M.S.L.	... ...	5853·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Spitzkop	65	17 25 24·52	5·2955161
Tafel Kop (E)	66	57 35 38·55	5·2560711
Baatjes Bult	69	112 30 35·05	4·9879039
Tafel Kop (D.K.)	70	203 45 42·99	5·2901225

FINAL RESULTS—*continued.*

BAATJES BULT.

Station No. 69.

	° ′ ″
Latitude	26 7 46·325.
Longitude	30 13 13·042.
Height above M.S.L.	6062·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Tafel Kop (E)	66	25 6 49·42	5·1693937
Sterkfontein	67	47 10 20·16	5·0421119
Wonderfontein	72	137 20 53·24	5·2050508
Verloren Vlei	71	171 39 38·46	5·4685053
Tafel Kop (D.K.)	70	280 7 54·41	5·3420965
Vlakfontein	68	292 37 49·96	4·9879089

TAFEL KOP (DUIVEL'S KANTOOR).

Station No. 70.

	° ′ ″
Latitude	25 44 27·252.
Longitude	30 43 58·175.
Height above M.S.L.	6128·4 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Vlakfontein	68	23 39 26·43	5·2901225
Baatjes Bult	69	49 54 27·48	5·3420965
Verloren Vlei	71	124 36 33·17	5·4098024
Mount Anderson	286	173 28 25·88	5·3819130

VERLOREN VLEI.

Station No. 71.

	° ′ ″
Latitude	25 20 16·729.
Longitude	30 5 33·465.
Height above M.S.L.	7454·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Belfast	74	6 7 8·41	5·1418436
Langekloof	75	18 41 8·94	5·0820245
Wonderfontein	72	21 26 31·11	5·2607546
Panplaats	73.	41 35 1·92	5·2114003
Groot Riet Vlei	79	66 51 17·18	5·0899814
Paarde Kop I.	80	133 4 50·35	5·1783898
Thama Koosh	287	176 18 23·45	5·3491011
Mount Anderson	236	243 21 27·07	5·3147838
Tafel Kop (D.K.)	70	304 53 6·81	5·4098024
Maré's Kop	76	340 41 20·65	4·9651473
Baatjes Bult	69	351 42 58·01	5·4685058

FINAL RESULTS—*continued.*

WONDERFONTEIN.

Station No. 72.

	° ′ ″
Latitude	25 48 16·883.
Longitude	29 53 24·373.
Height above M.S.L.	5883·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Panplaats	73	139 19 24·49	4·8016307
Verloren Vlei	71	201 31 45·81	5·2607546
Baatjes Bult	69	317 29 33·71	5·2050508
Sterkfontein	67	351 55 56·13	5·2896535

PANPLAATS.

Station No. 73.

	° ′ ″
Latitude	25 40 20·923.
Longitude	29 45 53·212.
Height above M.S.L.	5766·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Rhenoster Kop I.	81	96 13 40·55	5·4339901
Groot Riet Vlei	79	176 8 24·60	4·8664312
Verloren Vlei	71	221 43 30·13	5·2114003
Langekloof	75	255 7 14·45	4·8813846
Belfast	74	279 51 55·67	4·9758529
Wonderfontein	72	319 22 40·42	4·8016307

BELFAST.

Station No. 74.

	° ′ ″
Latitude	25 43 0·468.
Longitude	30 2 52·130.
Height above M.S.L.	6344·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Panplaats	73	99 44 33·90	4·9758529
Groot Riet Vlei	79	132 15 39·52	5·1234171
Langekloof	75	151 5 13·82	4·6105555
Verloren Vlei	71	186 8 12·94	5·1413433
Maré's Kop	76	221 51 4·17	4·8317720

FINAL RESULTS—*continued.*

LANGEKLOOF.

Station No. 75.

	° ′ ″
Latitude	25 37 6·746.
Longitude	29 59 16·687.
Height above M.S.L.	6341·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Panplaats	73	75 1 26·71	4·8813846
Groot Riet Vlei	79	124 20 14·14	4·9785171
Verloren Vlei	71	198 43 51·02	5·0320245
North end of Base	78	213 22 5·14	4·7056424
Maré's Kop	76	257 9 3·52	4·8240628
South end of Base	77	306 17 20·83	4·5263775
Belfast	74	331 6 47·14	4·6105555

MARÉ'S KOP.

Station No. 76.

	° ′ ″
Latitude	25 34 39·362.
Longitude	30 11 6·757.
Height above M.S.L.	6615·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Belfast	74	41 47 30·08	4·8317720
South end of Base	77	47 26 57·25	4·7111696
Langekloof	75	77 3 56·73	4·8240628
North end of Base	78	126 32 28·58	4·6648251
Verloren Vlei	71	160 38 57·39	4·9651473

SOUTH END OF BELFAST BASE.

Station No. 77.

	° ′ ″
Latitude	25 40 23·663.
Longitude	30 4 12·715.
Height above M.S.L.	6391·4 feet. 6399·9 „ *

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Langekloof	75	126 15 12·71	4·5263775
North end of Base	78	180 44 17·37	4·7944751
Maré's Kop	76	227 29 56·32	4·7111696

* By Geodetic Levelling.

FINAL RESULTS—*continued.*

NORTH END OF BELFAST BASE:

Station No. 78.	° ′ ″
Latitude	25 30 6·625.
Longitude	30 4 21·474.
Height above M.S.L.	6605·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
South end of Base	77	0 44 13·59	4·7944751
Langekloof	75	33 19 53·64	4·7056424
Maré's Kop	76	306 35 18·32	4·6648251

GROOT RIET VLEI.

Station No. 79.	° ′ ″
Latitude	25 28 14·282.
Longitude	29 44 59·209.
Height above M.S.L.	5996·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Rhenoster Kop I..	81	80 36 31·60	5·4292515*
Paarde Kop I.	80	181 16 27·16	5·1800731
Verloren Vlei	71	247 0 6·63	5·0899814
Langekloof	75	304 26 23·89	4·9785171
Belfast	74	312 23 23·01	5·1284171
Panplaats	73	356 8 47·92	4·8664312

PAARDE KOP I.

Station No. 80.	° ′ ″
Latitude	25 3 15·088.
Longitude	29 45 35·813.
Height above M.S.L.	6220·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Groot Riet Vlei	79	1 16 11·54	5·1800781
Rhenoster Kop I..	81	53 58 37·62	5·5210221
Quaggafontein	82	109 4 15·15	5·2690887
Verloren Vlei	71	313 13 20·21	5·1788898

Final Results—*continued.*

RHENOSTER KOP I.

Station No. 81.

	° ′ ″
Latitude	25 35 20·636.
Longitude	28 56 43·953.
Height above M.S.L.	5532·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Cable Hill..	84	81 36 0·44	5·4125418
Zwartkloof	83	135 31 30·73	5·5670821
Quaggafontein	82	200 17 1·68	5·4849272
Paarde Kop I	80	234 19 31·60	5·5210221
Groot Riet Vlei	79	260 57 19·42	5·4292515
Panplaats	78	276 35 5·33	5·4339901

QUAGGAFONTEIN.

Station No. 82.

	° ′ ″
Latitude	24 53 10·244.
Longitude	29 13 48·730.
Height above M.S.L.	3738·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Rhenoster Kop I	81	20 9 44·74	5·4849272
Zwartkloof	83	91 10 46·78	5·5477830
Paarde Kop I	80	289 17 40·23	5·2690887

ZWARTKLOOF.

Station No. 83.

	° ′ ″
Latitude	24 51 44·585.
Longitude	28 9 56·883.
Height above M.S.L.	4935·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Boshofsberg	85	90 59 3·76	5·2450694
Quaggafontein	82	271 37 38·60	5·5477830
Rhenoster Kop I	81	315 51 27·10	5·5670821
Cable Hill..	84	359 48 20·17	5·4787269

Final Results—*continued.*

CABLE HILL.

Station No. 84.

	° ′ ″
Latitude	25 41 27·325.
Longitude	28 10 8·050.
Height above M.S.L.	4846·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Observatory Hill (Johannesburg) ..	96	9 33 34·55	5·2592632
Daspoort	252	58 34 46·80	4·4426029
Nooitgedacht I	86	73 30 50·56	5·3897025
Boshofsberg	85	149 49 27·15	5·5462847
Zwartkloof	83	179 48 15·41	5·4787269
Rhenoster Kop I	81	261 56 10·29	5·4125418
Koedoes Poort	255	298 58 26·43	4·5261560
Meintjes Kop	254	317 33 48·02	4·3670315
Camp	256	318 53 56·05	4·5806639
Klappor Kop	257	337 25 23·46	4·5432646
Muckleneuk	258	338 33 57·63	4·4636922

BOSHOFSBERG.

Station No. 85.

	° ′ ″
Latitude	24 51 11·275.
Longitude	27 38 8·406.
Height above M.S.L.	5370·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Nooitgedacht I	86	5 20 59·46	5·5654013
Pilandsberg	87	58 11 21·97	5·3467686
Zwartkloof	83	271 12 26·03	5·2450694
Cable Hill..	84	330 8 6·70	5·5462847

NOOITGEDACHT I.

Station No. 86.

	° ′ ″
Latitude	25 51 36·841.
Longitude	27 31 53·221.
Height above M.S.L.	6076·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Blijvooruitzicht	97	12 32 59·92	5·3240576
Tafel Kop..	88	83 17 39·87	5·4258578
Pilandsberg	87	148 12 11·20	5·4668230
Boshofsberg	85	185 23 40·15	5·5654013
Cable Hill..	84	253 47 28·47	5·3897025
Observatory Hill (Johannesburg) ..	96	303 24 3·98	5·3310007

PILANDSBERG.

Station No. 87.

		° ′ ″
Latitude	... ...	25 10 27·664.
Longitude	... .	27 3 53·025.
Height above M.S.L.	... ...	5521·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Tafel Kop	88	21 42 49·63	5·4787062
Kaalkop I..	89	38 25 34·52	5·2673528
Enzelberg	91	72 7 14·07	5·4662622
Boshofsberg	85	238 25 51·07	5·3467686
Nooitgedacht I	86	328 24 15·01	5·4668230

TAFEL KOP.

Station No. 88.

		° ′ ″
Latitude	... ...	25 56 37·134.
Longitude	... ...	26 43 32·789.
Height above M.S.L.	... ...	5673·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Onverwacht	90	122 21 50·04	5·2653849
Kaalkop I..	89	178 36 11·27	5·1296551
Pilandsberg	87	201 51 36·11	5·4787062
Nooitgedacht I	86	263 38 46·89	5·4258578

KAALKOP I.

Station No. 89.

		° ′ ″
Latitude	... ...	25 34 22·419.
Longitude	... ...	26 42 56·907.
Height above M.S.L.	... ...	4890·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Onverwacht	90	76 39 30·31	5·1946388
Enzelberg	91	108 47 53·19	5·2867643
Pilandsberg	87	218 34 32·80	5·2673528
Tafel Kop	88	358 36 26·86	5·1296551

FINAL RESULTS—*continued.*

ONVERWACHT.

Station No. 90.

	° ′ ″
Latitude	25 40 17·606.
Longitude	26 15 12·156.
Height above M.S.L.	5105·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Witkop I	92	67 18 27·38	4·8910248
Vergenoeg	93	111 48 44·30	4·9686348
Enzelberg	91	173 22 41·85	4·9654783
Kaalkop I	89	256 51 30·21	5·1946388
Tafel Kop	88	302 34 10·41	5·2653849

ENZELBERG.

Station No. 91.

	° ′ ″
Latitude	25 25 8·839.
Longitude	26 13 16·001.
Height above M.S.L.	4918·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Witkop I	92	26 40 30·10	5·1843224
Vergenoeg	93	52 57 32·55	4·9771855
Pilandsberg	87	252 28 51·83	5·4662622
Kaalkop I	89	289 0 39·78	5·2367643
Onverwacht	90	353 23 31·94	4·9654783

WITKOP I.

Station No. 92.

	° ′ ″
Latitude	25 45 14·346.
Longitude	26 2 7·057.
Height above M.S.L.	4985·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Malopos Oog	224	0 57 33·59	4·6115370
Grootfontein	226	40 0 20·55	4·9378790
South end of Base	95	54 52 54·09	4·4145850
Klippan	227	104 19 34·38	4·8001619
North end of Base	94	133 42 44·22	4·7500503
Vergenoeg	93	167 22 2·49	4·8209352
Enzelberg	91	206 45 19·00	5·1843224
Onverwacht	90	247 24 8·00	4·8910248

FINAL RESULTS—*continued.*

VERGENOEG.

Station No. 93.

° ′ ″
Latitude ... ... 25 34 34·351.
Longitude ... ... 25 59 28·922.
Height above M.S.L. ... ... 4819·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
South end of Base	95	4 52 58·78	4·9022196
Klippan	227	48 37 59·44	4·8308715
North end of Base	94	45 29 24·86	4·5647995
Enzelberg	91	238 8 28·59	4·9771855
Onverwacht	90	291 55 32·71	4·9686348
Witkop I.	92	347 23 10·98	4·8209352

NORTH END OF OTTOSHOOP BASE.

Station No. 94.

° ′ ″
Latitude ... ... 25 38 49·196.
Longitude ... ... 25 54 42·853.
Height above M.S.L. ... ... 4689·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Vergenoeg	93	225 31 28·02	4·5647995
Witkop I.	92	313 45 56·86	4·7500503
South end of Base	95	340 13 25·38	4·7578932

SOUTH END OF OTTOSHOOP BASE.

Station No. 95.

° ′ ″
Latitude ... ... 25 47 42·312.
Longitude ... ... 25 58 14·590.
Height above M.S.L. ... ... 4733·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
North end of Base	94	160 11 58·49	4·7578932
Vergenoeg	93	184 53 25·95	4·9022196
Witkop I.	92	234 54 35·18	4·4145850

FINAL RESULTS—*continued.*

OBSERVATORY HILL (JOHANNESBURG).

Station No. 96.

	° ′ ″
Latitude	26 11 1·575.
Longitude	28 4 36·899.
Height above M.S.L.	5930·0 feet. 5936·1 „ *

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kliprivierberg	267	0 50 16·02	4·4960190
Blijvooruitzicht	97	68 23 57·67	5·3825450
Nooitgedacht I.	86	128 9 42·47	5·3310007
Driefontein	264	162 47 31·36	4·6966281
Cable Hill	84	189 35 59·39	5·2592622
Klipfontein	262	214 39 22·79	4·7506204
Germiston	265	271 33 49·12	4·3591274
P6 Beacon	266	307 52 20·62	4·5458072
Paarde Kop II.	98	343 51 45·71	5·1181152

* By Geodetic Levelling.

BLIJVOORUITZICHT.

Station No. 97.

	° ′ ″
Latitude	26 25 35·486.
Longitude	27 23 29·180.
Height above M.S.L.	5755·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Nooitgedacht I.	86	192 36 42·01	5·3240576
Observatory Hill (Johannesburg)	96	248 42 11·26	5·3825450
Paarde Kop II.	98	278 25 59·87	5·4207888
Witkop II.	99	347 50 8·20	5·1481650

PAARDE KOP II.

Station No. 98.

	° ′ ″
Latitude	26 31 50·188.
Longitude...	28 11 18·531.
Height above M.S.L.	6148·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Elandskop I	100	12 31 10·67	5·3908590
Witkop II.	99	66 50 2·98	5·3995787
Blijvooruitzicht	97	98 4 40·52	5·4207888
Observatory Hill (Johannesburg)	96	163 48 47·41	5·1181152

Final Results—*continued.*

WITKOP II.

Station No. 99.

	° ′ ″
Latitude	26 48 1·584.
Longitude...	27 28 52·548.
Height above M.S.L.	5534·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Vliegenkraal	101	26 21 59·02	5·1201440
Blijvooruitzicht	97	167 47 38·34	5·1431650
Paarde Kop II	98	247 9 5·58	5·3995787
Elandskop I	100	308 52 29·43	5·3557242

ELANDSKOP I.

Station No. 100.

	° ′ ″
Latitude	27 11 27·791.
Longitude...	28 1 28·136.
Height above M.S.L.	5374·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Spitzkop II	102	3 34 38·91	4·9221610
Vliegenkraal	101	95 37 58·19	5·3736628
Witkop II..	99	128 37 41·73	5·3557242
Paarde Kop II	98	192 35 37·42	5·3908590

VLIEGENKRAAL.

Station No. 101.

	° ′ ″
Latitude	27 7 31·281.
Longitude...	27 18 4·416.
Height above M.S.L.	5036·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Rhenoster Kop II	105	19 15 3·82	5·0586523
Witkop II..	99	206 26 52·89	5·1201440
Elandskop I	100	275 57 46·67	5·3736628
Spitzkop II	102	295 11 57·07	5·4040835
Liebenberg Stroom	103	321 11 58·59	5·3672248
Doornkop	104	358 28 20·55	5·2648320

Final Results—*continued.*

SPITZKOP II.

Station No. 102.

	° ′ ″
Latitude	27 25 13·977.
Longitude...	28 0 30·259.
Height above M.S.L.	5583·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Liebenberg Stroom	103	48 17 0·21	5·0463453
Vliegenkraal	101	114 52 30·48	5·4040835
Elandskop I	100	183 35 5·47	4·9221610
Elandskop II	111	336 30 20·37	4·9597309

LIEBENBERG STROOM.

Station No. 103.

	° ′ ″
Latitude	27 37 26·309.
Longitude...	27 45 7·005.
Height above M.S.L.	5368·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Rietfontein	110	23 23 2·10	5·0763212
Doornkop	104	89 12 9·92	5·0970736
Vliegenkraal	101	140 59 27·50	5·3672248
Spitzkop II	102	228 24 6·88	5·0463453
Elandskop II	111	274 41 32·19	5·0783384
Kaffir Kop	112	337 17 18·27	5·2807061

DOORNKOP.

Station No. 104.

	° ′ ″
Latitude	27 37 41·604.
Longitude	27 21 56·964.
Height above M.S.L.	4843·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Boschrand..	106	56 21 31·94	4·8665598
East end of Base	109	92 31 40·41	4·6715219
West end of Base	108	97 49 28·51	5·0478914
Rhenoster Kop II	105	141 51 0·99	4·9778118
Vliegenkraal	101	178 26 33·62	5·2648320
Liebenberg Stroom	103	269 22 54·49	5·0970736
Rietfontein	110	324 21 32·09	5·1281950

FINAL RESULTS—*continued.*

RHENOSTER KOP II.

Station No. 105.

	° ′ ″
Latitude	27 25 21·222.
Longitude	27 11 5·654.
Height above M.S.L.	4930·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Boschrand	106	1 20 27·28	5·0625609
Braunzijn Kop	107	27 30 42·33	5·2442978
West end of Base	108	41 11 1·13	4·8975530
Nooitverwacht	176	81 21 26·23	5·2818150
Bovenlands Plaats	235	114 38 56·73	5·0817729
Vliegenkraal	101	199 18 15·72	5·0586523
Doornkop	104	321 56 1·99	4·9778113
East end of Base	109	350 51 21·90	4·8669088

BOSCHRAND.

Station No. 106.

	° ′ ″
Latitude	27 44 24·602.
Longitude	27 10 35·577.
Height above M.S.L.	4752·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Braunzijn Kop	107	62 50 55·46	4·9448658
West end of Base	108	138 38 55·25	4·8728959
Rhenoster Kop II	105	181 20 41·20	5·0625609
East end of Base	109	198 36 6·87	4·6546641
Doornkop	104	236 26 48·51	4·8665598
Rietfontein	110	295 56 45·61	5·1876146

BRAUNZIJN KOP.

Station No. 107.

	° ′ ″
Latitude	27 51 1·844.
Longitude	26 56 2·531.
Height above M.S.L.	4815·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Theron's Kop	174	16 13 50·97	5·2470695
Zoetvlei	175	90 54 43·27	5·2674005
Nooitverwacht	176	139 45 20·40	5·2216441
West end of Base	108	196 55 28·99	5·0022040
Rhenoster Kop II	105	207 37 41·26	5·2442973
East end of Base	109	228 18 3·08	5·0950772
Boschrand	106	242 57 42·58	4·9448658

FINAL RESULTS—*continued.*

WEST END OF KROONSTAD BASE.

Station No. 108.

	° ′ ″
Latitude	27 35 9·560.
Longitude	27 1 27·664.
Height above M.S.L.	4692·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Braunzijn Kop	107	16 52 52·76	5·0022040
Rhenoster Kop II	105	221 15 28·06	4·8975580
Doornkop	104	277 58 58·18	5·0478914
East end of Base	109	281 48 4·38	4·8133512
Boschrand..	106	318 43 9·64	4·8728959

EAST END OF KROONSTAD BASE.

Station No. 109.

	° ′ ″
Latitude	27 37 20·831.
Longitude	27 13 15·684.
Height above M.S.L.	4691·7 feet. 4684·4 „ *

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Boschrand	106	18 34 52·00	4·6546641
Braunzijn Kop	107	48 10 2·24	5·0950772
West end of Base	108	101 42 36·26	4·8133512
Rhenoster Kop II.	105	170 50 21·82	4·8669088
Doornkop	104	272 35 42·13	4·6715219

* By Geodetic Levelling.

RIETFONTEIN.

Station No. 110.

	° ′ ″
Latitude	27 55 29·550.
Longitude	27 36 19·577.
Height above M.S.L.	5243·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Mijnhardt's Rust	113	37 13 10·56	4·9019086
Boschrand..	106	115 44 44·72	5·1876146
Doornkop	104	144 14 50·08	5·1231950
Liebenberg Stroom	103	203 27 7·88	5·0763212
Kaffir Kop	112	298 54 38·39	5·1403090

FINAL RESULTS—*continued.*

ELANDSKOP II.

Station No. 111.

	° ′ ″
Latitude	27 39 1·564.
Longitude	28 7 14·289.
Height above M.S.L.	5785·4 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kaffir Kop	112	15 11 25·48	5·2365859
Liebenberg Stroom	103	94 31 16·51	5·0783384
Spitzkop II.	102	156 27 18·59	4·9597309
Vierfontein	178	275 58 40·08	5·1794614
Langberg II.	177	330 4 36·39	5·3896107

KAFFIR KOP

Station No. 112.

	° ′ ″
Latitude	28 6 28·979.
Longitude	27 58 49·816.
Height above M.S.L.	5980·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Mijnhardt's Rust	113	90 55 25·07	5·2284274
Rietfontein	110	118 44 4·15	5·1408090
Liebenberg Stroom	103	157 10 58·69	5·2807061
Elandskop II.	111	195 15 21·38	5·2365859
Langberg II.	177	285 28 23·58	5·2899535
Zwartkrans	114	355 50 15·65	5·1666115

MIJNHARDT'S RUST.

Station No. 113.

	° ′ ″
Latitude	28 5 58·357.
Longitude	27 27 20·754.
Height above M.S.L.	5186·3 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Rhebokberg	115	1 1 11·41	5·4391470
Rietfontein	110	217 17 23·63	4·9019086
Kaffir Kop	112	271 10 14·96	5·2284274
Zwartkrans	114	309 54 33·49	5·3684918

ZWARTKRANS.

Station No. 114.

	° ′ ″
Latitude	28 30 38·293.
Longitude	28 0 49·210.
Height above M.S.L.	7690·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Machache	116	6 56 50·00.	5·4920053
Rhebokberg	115	55 33 51·05	5·3473061
Mijnhardt's Rust	118	129 38 41·13	5·3684913
Kaffir Kop	112	175 49 19·03	5·1666115

RHEBOKBERG.

Station No. 115.

	° ′ ″
Latitude	28 51 19·610.
Longitude	27 26 25·739.
Height above M.S.L.	6176·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Mabula	117	17 33 28·05	5·2653174
Mijnhardt's Rust	118	181 1 37·64	5·4391470
Zwartkrans	114	235 50 21·45	5·3473061
Machache	116	321 36 26·08	5·3684230

MACHACHE.

Station No. 116.

	° ′ ″
Latitude	29 21 29·277.
Longitude	27 53 44·895.
Height above M.S.L.	9471·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Thaba Tsueu	119	42 2 40·48	5·3872192
Mabula	117	91 54 1·49	5·3026819
Rhebokberg	115	141 23 8·72	5·3684230
Zwartkrans	114	187 0 15·29	5·4920053
Thaba Putsua	118	356 36 5·81	5·1317672

FINAL RESULTS—*continued.*

MABULA.

Station No. 117.

	° ′ ″
Latitude	29 20 18·015.
Longitude	27 15 57·970.
Height above M.S.L.	6688·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Aasvogel Berg	127	10 56 37·56	5·5496335
Jammersberg	120	29 53 17·19	5·1854239
Rhebokberg	115	197 38 28·33	5·2653174
Machache..	116	272 12 32·56	5·3026819
Thaba Putsua	118	304 31 5·38	5·4019779
Thaba Tsueu	119	342 10 10·49	5·2476742

THABA PUTSUA.

Station No. 118.

	° ′ ″
Latitude	29 43 47·785.
Longitude	27 55 15·954.
Height above M.S.L.	10157·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Nthodimonate	128	10 57 27·20	5·4506405
Aasvogel Berg	127	52 58 55·72	5·5855614
Thaba Tsueu	119	80 17 55·63	5·1926544
Mabula	117	124 11 43·01	5·4019779
Machache	116	176 35 20·91	5·1817672

THABA TSUEU.

Station No. 119.

	° ′ ″
Latitude	29 48 4·545.
Longitude	27 26 12·650.
Height above M.S.L.	7590·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Gobo Gobo	124	58 28 36·68	5·1203626
Dikhoele	121	65 12 51·81	4·7709150
Jammersberg	120	105 7 57·86	5·1812088
Mabula	117	162 5 7·15	5·2476742
Machache	116	222 16 16·09	5·3372190
Thaba Putsua	118	260 32 21·10	5·1926544

FINAL RESULTS—*continued.*

JAMMERSBERG.

Station No. 120.

	° ′ ″
Latitude	29 42 12·659.
Longitude	27 1 32·065.
Height above M.S.L.	5693·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Koesberg	126	5 57 26·47	5·3145299
North End of Base	122	60 28 54·98	4·2324540
Lemoenfontein	125	90 6 23·95	5·2984993
Mabula	117	210 0 23·86	5·1854239
Thaba Tsueu	119	285 20 12·61	5·1812083
Dikhoele	121	308 9 4·93	4·9896939
Gobo Gobo	124	350 21 3·21	5·0247167
South End of Base	123	355 48 4·72	4·8844428
Aasvogel Berg	127	357 42 24·57	5·3332096

DIKHOELE.

Station No. 121.

	° ′ ″
Latitude	29 52 9·041.
Longitude	27 16 4·219.
Height above M.S.L.	6926·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Gobo Gobo	124	53 10 5·25	4·8672366
South end of Base	123	77 7 47·31	4·8632172
North end of Base	122	119 24 19·36	5·0225740
Jammersberg	120	128 1 51·67	4·9896939
Thaba Tsueu	119	245 17 54·51	4·7709150

NORTH END OF WEPENER BASE.

Station No. 122.

	° ′ ″
Latitude	29 43 35·929.
Longitude	26 58 43·517.
Height above M.S.L.	4802·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Jammersberg	120	240 30 18·53	4·2324540
Dikhoele	121	299 32 56·53	5·0225740
Gobo Gobo	124	341 15 14·03	5·0057505
South end of Base	123	343 16 18·17	4·8514527

FINAL RESULTS—*continued.*

SOUTH END OF WEPENER BASE.

Station No. 123.

	° ′ ″
Latitude	29 54 49·277.
Longitude	27 2 35·819.
Height above M.S.L.	5251·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
North end of Base	122	163 14 22·65	4·8514527
Jammersberg	120	175 47 33·02	4·8844428
Dikhoele	121	257 14 30·18	4·8632172
Gobo Gobo	124	336 30 36·55	4·4835590

GOBO GOBO.

Station No. 124.

	° ′ ″
Latitude	29 59 25·686.
Longitude	27 4 53·817.
Height above M.S.L.	5874·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Koesberg	126	21 11 33·12	5·0341340
Lemoenfontein	125	115 46 39·65	5·3812454
South end of Base	123	156 29 27·65	4·4835590
North end of Base	122	161 12 9·67	5·0057505
Jammersberg	120	170 19 22·80	5·0247167
Dikhoele	121	233 15 39·74	4·8672366
Thaba Tsueu	119	238 39 14·08	5·1203626
Aasvogel Berg	127	335 58 5·72	5·0462054

LEMOENFONTEIN.

Station No. 125.

	° ′ ″
Latitude	29 42 3·665.
Longitude	26 23 57·612.
Height above M.S.L.	5902·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
De Put	142	37 5 26·08	5·3821055
Lokshoek	139	93 58 56·69	5·4137490
Jammersberg	120	270 25 1·02	5·2984993
Gobo Gobo	124	296 7 2·03	5·3812454
Koesberg	126	319 30 52·94	5·4338441

Final Results—*continued.*

KOESBERG.

Station No. 126.

	° ′ ″
Latitude	30 16 3·877.
Longitude	26 57 27·903.
Height above M.S.L.	6813·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
De Put	142	96 16 36·57	5·4883740
Lemoenfontein	125	139 14 8·25	5·4338441
Jammersberg	120	185 59 28·50	5·3145299
Gobo Gobo	124	201 15 16·95	5·0341340
Aasvogel Berg	127	288 28 2·86	4·5004378

AASVOGEL BERG.

Station No. 127

	° ′ ″
Latitude	30 17 43·006.
Longitude	27 3 10·358.
Height above M.S.L.	7250·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Koesberg	126	108 25 10·18	4·5004378
Jammersberg	120	177 41 35·48	5·3382096
Gobo Gobo	124	184 41 31·84	5·0462054
Mabula	117	191 2 59·26	5·5496335
Thaba Putsua	118	238 24 59·16	5·5355614
Nthodimonate	128	288 10 7·74	5·3643098
Helvelyn	129	334 46 7·17	5·2146856

NTHODIMONATE.

Station No. 128.

	° ′ ″
Latitude	30 29 30·433.
Longitude	27 45 2·806.
Height above M.S.L.	8831·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Helvelyn	129	62 48 20·71	5·2257740
Aasvogel Berg	127	107 48 56·59	5·3643098
Thaba Putsua	118	191 2 34·81	5·4506405
Bendearg	130	342 17 46·77	5·3732557

Final Results—*continued.*

HELVELYN.

Station No. 129.

	° ′ ″
Latitude	30 42 10·226.
Longitude	27 16 30·762.
Height above M.S.L.	8155·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Aasvogel Berg	127	154 39 20·95	5·2146856
Nthodimonate	128	242 57 52·15	5·2257740
Bendearg	130	304 0 12·70	5·4251836
Waschbank Peak..	131	344 38 31·30	5·3199630

BENDEARG.

Station No. 130.

	° ′ ″
Latitude	31 6 36·715.
Longitude	27 58 48·906.
Height above M.S.L.	9084·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Waschbank Peak..	131	71 59 33·68	5·2392928
Helvelyn	129	123 38 28·99	5·4251836
Nthodimonate	128	162 10 43·75	5·3782557
Xuka	10	355 57 52·65	4·8360795

WASCHBANK PEAK.

Station No. 131.

	° ′ ″
Latitude	31 15 23·652.
Longitude	27 27 8·144.
Height above M.S.L.	8428·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Helvelyn	129	164 33 3·21	5·3199630
Bendearg	130	252 15 57·86	5·2392928
Xuka	10	275 14 23·48	5·2316311
Lubisi	8	356 2 51·25	5·2767092

FINAL RESULTS—*continued.*

ELANDSBERG II.

Station No. 132.

	° ′ ″
Latitude	29 51 19·584.
Longitude	23 50 39·680.
Height above M.S.L.	4393·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Joostenberg	144	174 45 35·82	4·8698848
Loskop	143	204 58 47·17	5·1710538
Orange River	134	242 33 17·35	5·1757130
Bester's Kop	133	297 11 26·17	5·1675877

BESTER'S KOP.

Station No. 133.

	° ′ ″
Latitude	30 2 22·607.
Longitude...	24 15 28·137.
Height above M.S.L.	4784·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Elandsberg II	132	116 59 8·12	5·1675877
Orange River	134	180 42 15·85	5·1345118
Wonderkloof	135	267 21 5·72	5·1423666

ORANGE RIVER.

Station No. 134.

	° ′ ″
Latitude	29 39 53·398.
Longitude...	24 15 47·131.
Height above M.S.L.	3893·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Bester's Kop	133	0 42 6·40	5·1345118
Elandsberg II	132	62 20 49·10	5·1757130
Loskop	143	132 39 23·48	4·9824066
Eckmond	146	161 33 28·51	5·0887166
Kolskop	147	201 2 24·74	5·2191770
Boschjes Pan	136	255 35 24·68	5·0128819
Wonderkloof	135	313 28 31·29	5·2759038

Final Results—*continued.*

WONDERKLOOF.

Station No. 135.

	° ′ ″
Latitude	30 1 16·497.
Longitude...	24 41 45·135.
Height above M.S.L.	4838·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bester's Kop	133	87 7 56·50	5·1423666
Orange River	134	133 15 35·98	5·2759088
Boschjes Pan	136	166 19 47·15	5·2088878
Platkop	137	218 2 39·79	5·2843580
Luipers Rand	140	258 12 45·74	5·2046723

BOSCHJES PAN.

Station No. 136.

	° ′ ″
Latitude	29 35 38·287.
Longitude...	24 34 37·139.
Height above M.S.L.	4496·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Orange River	134	75 26 6·01	5·0128819
Platkop	137	271 26 49·01	5·1943688
Wonderkloof	135	346 23 19·90	5·2088878

PLATKOP.

Station No. 137.

	° ′ ″
Latitude	29 36 14·111.
Longitude...	25 4 8·677.
Height above M.S.L.	4834·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Wonderkloof	135	37 51 31·82	5·2843580
Boschjes Pan	136	91 12 14·00	5·1943688
Lokshoek	139	275 50 11·68	5·2169637
Fauresmith Hill	138	300 32 8·70	5·0004924
Luipers Rand	140	341 59 24·08	5·0963522

FINAL RESULTS—*continued.*

FAURESMITH HILL.

Station No. 138.

	° ′ ″
Latitude	29 44 36·650.
Longitude...	25 20 26·762.
Height above M.S.L.	5152·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Luipers Rand	140	84 55 51·71	4·9185819
Platkop	137	120 24 4·49	5·0004924
Lokshoek	139	246 10 19·46	4·9287703
Drie Baden	141	346 27 40·89	5·0760445

LOKSHOEK.

Station No. 139.

	° ′ ″
Latitude	29 38 56·404.
Longitude	25 35 6·586.
Height above M.S.L.	5010·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Drie Baden	141	18 10 0·91	5·1996247
Fauresmith Hill	138	66 8 8·59	4·9287703
Platkop	137	95 34 58·18	5·2169687
Lemoenfontein	125	274 23 7·79	5·4187490
De Put	142	326 7 38·31	5·3601767

LUIPERS RAND.

Station No. 140.

	° ′ ″
Latitude	29 55 49·187.
Longitude	25 11 27·305.
Height above M.S.L.	5404·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Wonderkloof	135	77 57 55·80	5·2046728
Platkop	137	161 55 46·31	5·0968522
Fauresmith Hill	138	215 0 20·11	4·9185819
Drie Baden	141	302 36 6·95	4·9515784

Final Results—*continued.*

DRIE BADEN.

Station No. 141.

	° ′ ″
Latitude … … … …	30 3 45·497.
Longitude … … … …	25 25 44·781.
Height above M.S.L. … …	5788·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Luipers Rand	140	122 28 58·25	4·9515784
Fauresmith Hill	138	166 25 2·34	5·0769445
Lokshoek	139	198 14 40·59	5·1996247
De Put	142	282 45 1·60	5·2589480

DE PUT.

Station No. 142.

	° ′ ″
Latitude … … … …	30 10 17·791.
Longitude … … … …	25 59 21·707.
Height above M.S.L. … …	5464·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Drie Baden	141	102 28 9·56	5·2589480
Lokshoek	139	145 55 27·71	5·3601767
Lemoenfontein	125	217 17 42·61	5·3321055
Koesberg	126	276 45 51·26	5·4883740

LOSKOP I.

Station No. 143.

	° ′ ″
Latitude … … … …	29 29 8·560.
Longitude … … … …	24 2 28·096.
Height above M.S.L. … …	3995·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Elandsberg II	132	24 52 56·49	5·1710538
Joostenberg	144	48 46 7·22	4·9648559
Leeuwberg	145	159 38 33·03	5·0463258
Eckmond	146	223 6 52·87	4·7229432
Orange River	134	312 45 57·86	4·9824066

FINAL RESULTS—*continued.*

JOOSTENBERG.

Station No. 144.

	° ′ ″
Latitude	29 39 8·989.
Longitude	23 49 22·974.
Height above M.S.L.	4089·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Leeuwberg	145	190 38 24·16	5·2246616
Loskop I	143	228 52 34·66	4·9643559
Elandsberg II	132	354 46 13·89	4·8698848

LEEUWBERG.

Station No. 145.

	° ′ ″
Latitude	29 11 56·275.
Longitude	23 55 9·716.
Height above M.S.L.	4013·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Joostenberg	144	10 30 33·80	5·2246616
Moller Pile	148	217 37 15·85	5·1939114
Kolskop	147	275 7 1·11	5·2298830
Eckmoud	146	311 16 54·04	4·9985631
Loskop I.	143	339 37 7·85	5·0463258

ECKMOND.

Station No. 146.

	° ′ ″
Latitude	29 22 46·541.
Longitude	24 9 16·250.
Height above M.S.L.	4164·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Loskop I.	143	43 3 32·30	4·7229432
Leeuwberg	145	131 9 59·90	4·9985631
Kolskop	147	241 38 9·70	5·0291876
Orange River	134	341 36 41·12	5·0387166

FINAL RESULTS—*continued.*

KOLSKOP.

Station No. 147.

	° ′ ″
Latitude	29 14 22·407.
Longitude	24 26 58·358.
Height above M.S.L.	4486·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Orange River	134	20 56 54·70	5·2191770
Eckmond	146	61 29 29·77	5·0291376
Leeuwberg	145	94 51 29·40	5·2298830
Moller Pile	148	151 47 45·85	5·1966354
Wolvedam	150	190 22 10·37	5·2473812
Scholtz Kop	149	212 12 40·95	5·1592726

MOLLER PILE.

Station No. 148.

	° ′ ″
Latitude	28 51 29·541.
Longitude	24 13 2·537.
Height above M.S.L.	3848·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Leeuwberg	145	37 28 35·27	5·1939114
Wolvedam	150	251 48 37·47	5·0486348
Scholtz Kop	149	276 20 19·97	5·1822485
Kolskop	147	331 54 31·69	5·1966354

SCHOLTZ KOP.

Station No. 149.

	° ′ ″
Latitude	28 54 12·869.
Longitude	24 41 23·723.
Height above M.S.L.	4178·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kolskop	147	32 5 40·46	5·1592726
Moller Pile	148	96 6 38·31	5·1822485
Wolvedam	150	188 49 32·89	4·8367589
Kimberley Hill	151	188 53 39·92	4·7715175
Tarantal Kop	152	216 13 22·34	5·0616442
Aasvogel Kop	162	237 55 13·68	5·0815165
Paardeberg	163	281 33 6·91	5·1115518

FINAL RESULTS—*continued.*

WOLVEDAM.

Station No. 150.

	° ′ ″
Latitude	28 45 40·856.
Longitude	24 32 55·808.
Height above M.S.L.	4016·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kolskop	147	10 19 17·07	5·2473812
Moller Pile	148	71 34 2·43	5·0486348
Distant Bush	154	208 6 57·08	4·8794043
Kimberley Hill	151	261 40 13·20	4·6968349
Scholtzkop	149	318 53 37·83	4·8367589

KIMBERLEY HILL.

Station No. 151.

	° ′ ″
Latitude	28 44 29·177.
Longitude...	24 42 8·804.
Height above M.S.L.	4016·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Scholtz Kop	149	3 53 18·19	4·7715175
Wolvedam	150	81 35 47·20	4·6968349
Distant Bush	154	167 8 13·37	4·7862047
Doornboom	153	200 30 52·59	4·8296942
Sand	155	213 9 57·84	4·6813895
Tarantal Kop	152	242 1 59·26	4·8607075

TARANTAL KOP.

Station No. 152.

	° ′ ″
Latitude	28 38 51·731.
Longitude...	24 54 8·058.
Height above M.S.L.	4308·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Scholtz Kop	149	36 7 14·41	5·0616442
Kimberley Hill	151	61 56 13·92	4·8607075
Distant Bush	154	108 6 52·77	4·9127081
Doornboom	153	125 47 56·91	4·6979689
Kameelpan II	167	202 9 33·10	4·6675247
Spion Kop..	166	245 30 5·62	4·5768961
Boshof Hill	165	248 25 13·20	4·9694957
Aasvogel Kop	162	310 9 45·01	4·6504543

Final Results—*continued.*

DOORNBOOM.

Station No. 153.

	° ′ ″
Latitude	28 34 2·607.
Longitude...	24 46 34·320.
Height above M.S.L.	3904·8 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kimberley Hill	151	20 28 45·27	4·8296942
Longitude Point	157	35 44 37·39	4·4806206
South end of Base	161	37 4 32·13	4·5223173
Warwicker	156	70 20 28·57	4·4953568
Distant Bush	154	84 19 0·97	4·5736804
Tarantal Kop	152	305 51 34·16	4·6979689
Sand	155	353 33 28·72	4·3659987

DISTANT BUSH.

Station No. 154.

	° ′ ″
Latitude	28 34 39·161.
Longitude...	24 39 36·193.
Height above M.S.L.	3869·3 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Wolvedam	150	28 3 45·00	4·8794043
Doornboom	153	264 22 20·95	4·5736804
Tarantal Kop	152	288 13 50·30	4·9127081
Sand	155	295 57 30·00	4·6468157
Longitude Point	157	316 47 6·46	4·4566094
South end of Base	161	323 4 2·24	4·4564762
Kimberley Hill	151	347 9 26·57	4·7862047

SAND.

Station No. 155.

	° ′ ″
Latitude	28 37 51·129.
Longitude...	24 47 3·563.
Height above M.S.L.	4029·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kimberley Hill	151	33 7 36·35	4·6813895
South end of Base	161	81 16 18·64	4·3606146
Longitude Point	157	85 51 41·22	4·3080422
Warwicker	156	111 22 37·12	4·5370522
Distant Bush	154	115 53 55·82	4·6468157
North end of Base	159	121 15 32·37	4·2625843
Doornboom	153	173 33 14·73	4·3659987

FINAL RESULTS—*continued.*

WARWICKER.

Station No. 156.

	° ′ ″
Latitude	28 35 46·707.
Longitude...	24 41 3·821.
Height above M.S.L.	3818·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Doornboom	153	250 23 6·69	4·4953568
North end of Base	159	280 35 1·83	4·2228001
Sand	155	291 25 29·40	4·5370522
Measured end of Base	158	311 20 17·97	4·2122981
South end of Base	161	329 40 56·51	4·2691330
Flag	160	356 55 6·29	4·1110325

LONGITUDE POINT.

Station No. 157.

	° ′ ″
Latitude	28 38 5·600.
Longitude	24 43 16·074.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Distant Bush	154	136 45 21·18	4·4566094
Doornboom	153	215 46 12·29	4·4806206
Sand	155	265 53 30·23	4·3080422

MEASURED END OF KIMBERLEY BASE.

Station No. 158.

	° ′ ″
Latitude	28 37 33·312.
Longitude	24 43 21·179.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
South end of Base	161	28 27 36·24	3·7780924
Flag Point	160	79 33 7·08	4·0697172
Warwicker	156	131 19 12·19	4·2122981
North end of Base	159	208 27 36·12	3·9425595

FINAL RESULTS—*continued.*

NORTH END OF KIMBERLEY BASE.

Station No. 159.

	° ′ ″
Latitude	28 36 17·048.
Longitude	24 44 8·016.
Height above M.S.L.	3805·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Well Point	160A	5 13 51·97	4·0616971
South end of Base	161	28 27 13·69	4·1690955
Measured end of Base	158	28 27 13·69	3·9425595
Warwicker	156	100 33 33·66	4·2228001
Sand	155	301 16 56·44	4·2625843

FLAG POINT.

Station No. 160.

	° ′ ″
Latitude	28 37 54·376.
Longitude	24 41 11·611.

Station Observed.	Station No.	*Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Warwicker	156	176 55 2·56	4·1110325
Measured end of Base	158	259 34 9·16	4·0697172
South end of Base	161	289 55 2·91	3·9650477

WELL POINT.

Station No. 160A.

	° ′ ″
Latitude	28 38 10·697.
Longitude	24 43 56·223.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
South end of Base	161	75 56 5·22	3·7900428
Measured end of Base	158	140 24 12·12	3·6902055
North end of Base	159	185 13 57·62	4·0616971

FINAL RESULTS—*continued.*

SOUTH END OF KIMBERLEY BASE.

Station No. 161.

	° ′ ″
Latitude	28 38 25·531.
Longitude	24 42 49·096.
Height above M.S.L.	3824·6* feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Flag Point	160	109 54 16·08	3·9656477
Distant Bush	154	148 2 29·88	4·4564762
Warwicker	156	149 40 6·09	4·2691330
North end of Base	159	208 27 51·50	4·1690955
Measured end of Base	158	208 27 51·50	3·7780924
Doornboom	153	217 6 19·96	4·5228173
Well Point	160A	255 56 37·28	3·7900428
Sand	155	261 18 20·59	4·8606146

* By levelling from railway datum 3839·8 feet.

AASVOGEL KOP.

Station No. 162.

	° ′ ″
Latitude	28 43 37·117.
Longitude	25 0 31·857.
Height above M.S.L.	4633·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Scholtz Kop	149	57 46 0·24	5·0815165
Tarantal Kop	152	130 6 40·77	4·6504548
Spion Kop..	166	180 10 39·80	4·6482884
Boshof Hill	165	219 42 18·34	4·9143964
Rondefontein	164	278 40 47·97	5·0436288
Paardeberg	163	344 38 48·32	4·9695370

PAARDEBERG.

Station No. 163.

	° ′ ″
Latitude	28 58 27·102.
Longitude	25 5 9·741.
Height above M.S.L.	4132·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Scholtz Kop	149	101 21 36·89	5·1115518
Aasvogel Kop	162	164 36 34·28	4·9695370
Rondefontein	164	229 5 46·91	5·0488060

FINAL RESULTS—*continued.*

RONDEFONTEIN.

Station No. 164.

	° ′ ″
Latitude	28 46 20·778.
Longitude	25 20 59·997.
Height above M.S.L.	4477·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Paardeberg	163	48 58 8·05	5·0488060
Aasvogel Kop	162	98 30 57·25	5·0436288
Boshof Hill	165	144 28 27·07	4·9913813
Kareelaagte	168	218 46 17·86	4·9602985

BOSHOF HILL.

Station No. 165.

	° ′ ″
Latitude	28 33 11·306.
Longitude	25 10 20·026.
Height above M.S.L.	4331·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Aasvogel Kop	162	39 37 36·43	4·9143964
Tarantal Kop	152	68 17 27·92	4·9694957
Spion Kop..	166	70 16 26·37	4·7446931
Kameelpan II.	167	97 6 51·27	4·8432179
Zwart Kop II.	133	176 56 19·88	4·3297628
Du Plessis Dam	169	226 43 19·69	5·1206484
Kareelaagte	168	274 21 39·41	5·0589732
Rondefontein	164	324 28 34·04	4·9913813

SPION KOP.

Station No. 166.

	° ′ ″
Latitude	28 36 16·598.
Longitude	25 0 33·406.
Height above M.S.L.	4282·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Aasvogel Kop	162	0 10 39·06	4·6482884
Tarantal Kop	152	65 27 1·00	4·5768961
Kameelpan II.	167	148 26 27·00	4·5078322
Boshof Hill	165	250 21 6·99	4·7446931

FINAL RESULTS—*continued.*

KAMEELPAN II.

Station No. 167.

	° ′ ″
Latitude	28 31 45·225.
Longitude	24 57 24·708.
Height above M.S.L.	3962·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Tarantal Kop	152	22 7 59·00	4·6675247
Boesman's Kop	184	196 54 37·20	4·8218341
Zwart Kop II.	183	259 31 20·78	4·8400835
Boshof Hill	165	277 13 1·72	4·8432179
Spion Kop..	166	328 27 57·24	4·5073822

KAREELAAGTE.

Station No. 168.

	° ′ ″
Latitude	28 34 35·865.
Longitude	25 31 40·966.
Height above M.S.L.	4411·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Rondefontein	164	38 41 10·30	4·9602985
Boshof Hill	165	94 11 26·92	5·0589782
Du Plessis Dam	169	169 29 39·25	5·0036863
Weltevreden	171	214 42 14·41	5·1806090
Bosberg	170	258 42 41·01	5·2610404

DU PLESSIS DAM.

Station No. 169.

	° ′ ″
Latitude	28 18 13·988.
Longitude	25 28 15·257.
Height above M.S.L.	4506·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Boshof Hill	165	46 34 47·81	5·1206484
Weltevreden	171	256 21 56·66	5·0328855
Kareelaagte	168	349 31 17·22	5·0036863

FINAL RESULTS—*continued.*

BOSBERG.

Station No. 170.

	° ′ ″
Latitude	28 28 38·218.
Longitude	26 5 5·272.
Height above M.S.L.	4755·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kareelaagte	168	78 26 43·81	5·2610404
Weltevreden	171	133 34 16·69	5·1084066
Biesie Pan..	172	188 11 16·87	4·9809438
Schoongezicht	173	241 12 3·71	5·0631278

WELTEVREDEN.

Station No. 171.

	° ′ ″
Latitude	28 14 1·150.
Longitude	25 47 45·664.
Height above M.S.L.	4511·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kareelaagte	168	34 34 35·50	5·1806090
Du Plessis Dam	169	76 12 43·34	5·0828355
Biesie Pan..	172	266 46 30·81	5·0286050
Bosberg	170	313 42 30·44	5·1084066

BIESIE PAN.

Station No. 172.

	° ′ ″
Latitude	28 13 0·214.
Longitude	26 7 37·630.
Height above M.S.L.	4524·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bosberg	170	8 10 4·58	4·9809438
Weltevreden	171	86 37 7·09	5·0286050
Zoet Vlei	175	209 1 34·71	5·1932586
Theron's Kop	174	279 58 33·40	5·3294014
Schoongezicht	173	293 57 46·12	4·9822656

FINAL RESULTS—*continued.*

SCHOONGEZICHT.

Station No. 173.

	° ′ ″
Latitude	28 19 25·291.
Longitude	26 23 59·156.
Height above M.S.L.	4653·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bosberg	170	61 8 4·40	5·0631278
Biesie Pan	172	113 50 1·24	4·9822656
Zoet Vlei	175	175 57 20·86	5·2451358
Theron's Kop	174	268 56 4·58	5·0883681

THERON'S KOP.

Station No. 174.

	° ′ ″
Latitude	28 19 0·813.
Longitude	26 46 50·184.
Height above M.S.L.	5177·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Schoongezicht	173	88 45 14·16	5·0883681
Bresie Pan	172	99 39 59·27	5·3294014
Zoet Vlei	175	141 58 8·08	5·3414527
Braunzijn Kop	107	196 18 10·99	5·2470695

ZOET VLEI.

Station No. 175.

	° ′ ″
Latitude	27 50 28·392.
Longitude	26 21 41·015.
Height above M.S.L.	4316·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Biesie Pan	172	28 54 58·40	5·1932586
Nooitverwacht	176	212 12 43·32	5·1654726
Braunzijn Kop	107	271 10 46·20	5·2674005
Theron's Kop	174	322 4 58·44	5·3414527
Schoongezicht	173	355 58 25·89	5·2451358

NOOITVERWACHT.

Station No. 176.

	° ′ ″
Latitude	27 30 1·249.
Longitude...	26 36 7·445.
Height above M.S.L.	4419·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Zoet Vlei	175	32 6 0·95	5·1654726
Vlaklaagte	233	180 3 19·52	5·0797078
Bovenlands Plaats	235	225 19 45·83	5·0489714
Rhenoster Kop II	105	261 37 33·83	5·2813150
Braunzijn Kop	107	319 54 35·47	5·2216441

LANGBERG II.

Station No. 177.

	° ′ ″
Latitude	28 14 4·447.
Longitude...	28 30 1·965.
Height above M.S.L.	6526·3 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kaffir Kop	112	105 13 39·72	5·2399535
Elandskop II	111	149 53 55·51	5·3896107
Vierfontein	178	187 55 7·69	5·2988860
Vaalbank Kop	179	237 37 14·45	5·3029244

VIERFONTEIN.

Station No. 178.

	° ′ ″
Latitude	27 41 32·490.
Longitude...	28 35 6·953.
Height above M.S.L.	5822·9 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Langberg II	177	7 52 44·67	5·2988860
Elandskop II	111	95 40 43·29	5·1794614
Kaal Kop II	180	255 40 16·46	5·1947745
Vaalbank Kop	179	302 9 13·87	5·2254733

FINAL RESULTS—*continued.*

VAALBANK KOP.

Station No. 179.

	° ′ ″
Latitude	27 56 15·646.
Longitude...	29 1 33·259.
Height above M.S.L.	6066·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Langberg II	177	57 22 24·02	5·3029244
Vierfontein	178	121 56 53·67	5·2254733
Kaal Kop II	180	184 0 17·03	5·1090480
Hermitage	181	236 41 2·00	5·0907958

KAAL KOP II.

Station No. 180.

	° ′ ″
Latitude	27 35 5·872.
Longitude	29 3 13·021.
Height above M.S.L.	6383·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Vaalbank Kop	179	3 59 30·56	5·1090480
Vierfontein	178	75 27 14·30	5·1947745
Gemsbokberg	182	249 12 53·30	5·1189880
Hermitage	181	302 45 39·78	5·0485164

HERMITAGE.

Station No. 181.

	° ′ ″
Latitude	27 45 3·968.
Longitude	29 20 39·572.
Height above M.S.L.	7664·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Vaalbank Kop	179	56 32 6·59	5·0907958
Kaal Kop II	180	122 37 33·82	5·0485164
Gemsbokberg	182	194 20 3·88	5·0419482
Drakensberg	58	286 27 0·21	5·0714628

FINAL RESULTS—*continued.*

GEMSBOKBERG.

Station No. 182

	° ′ ″
Latitude	27 27 27·169.
Longitude	29 25 42·250.
Height above M.S.L.	6870·5 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Hermitage	181	14 17 48·68	5·0419432
Kaal Kop II	180	69 2 29·85	5·1139880
Inkwelo	59	279 50 24·51	5·1214689
Drakensberg	58	328 28 39·39	5·2155728

ZWART KOP II.

Station No. 183.

	° ′ ″
Latitude	28 29 40·039.
Longitude	25 10 7·240.
Height above M.S.L.	4177·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kameelpan II	167	79 25 16·79	4·8400835
Boesman's Kop	184	136 4 58·44	4·8477897
Uitkyk	185	198 21 27·35	4·9593104
Boshof Hill	165	356 56 25·99	4·3297628

BOESMAN'S KOP.

Station No. 184.

	° ′ ″
Latitude	28 21 17·363.
Longitude	25 1 0·456.
Height above M.S.L.	4101·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kameelpan II	167	16 52 54·44	4·8213341
Leeuwlaagte	186	195 2 41·91	4·6171683
Uitkyk	185	245 21 27·42	4·9312071
Zwart Kop II	183	316 9 18·71	4·8477897

FINAL RESULTS—*continued.*

UITKYK.

Station No. 185.

	° ′ ″
Latitude	28 15 24·229.
Longitude	25 15 27·907.
Height above M.S.L.	4656·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Zwart Kop II	183	13 18 54·96	4·9593104
Boesman's Kop	184	65 14 36·10	4·9312071
Leeuwlaagte	186	93 39 33·11	4·8258949
Winterhoek	187	151 2 51·82	4·6334885
Boomplaats	188	208 24 8·28	4·8058413

LEEUWLAAGTE.

Station No. 186.

	° ′ ″
Latitude	28 14 41·323.
Longitude	25 3 0·653.
Height above M.S.L.	4345·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ′	
Boesman's Kop	184	15 1 44·93	4·6171683
Winterhoek	187	234 9 57·31	4·7546083
Uitkyk	185	273 45 31·81	4·8258949

WINTERHOEK.

Station No. 187.

	° ′ ″
Latitude	28 9 11·596.
Longitude	25 11 35·368.
Height above M.S.L.	4318·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Leeuwlaagte	186	54 5 54·09	4·7546083
Bethel Pella	190	159 42 1·24	4·6996780
Houtnek	189	211 24 25·64	4·9239654
Boomplaats	188	250 3 12·51	4·7365164
Uitkyk	185	331 4 41·73	4·6334885

FINAL RESULTS—*continued.*

BOOMPLAATS.

Station No. 188.

	°	′	″
Latitude	28	6	7·116.
Longitude	25	21	7·549.
Height above M.S.L.	4206·8 feet.		

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Uitkyk	185	28 21 27·89	4·8058413
Winterhoek	187	69 58 42·76	4·7365164
Houtnek	189	171 52 28·19	4·7289340

HOUTNEK.

Station No. 189.

	°	′	″
Latitude	27	57	21·973.
Longitude	25	19	43·118.
Height above M.S.L.	4197·6 feet.		

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Winterhoek	187	31 20 36·23	4·9239654
Bethel Pella	190	67 57 17·19	4·8189386
Schoonheid	191	118 38 52·37	4·9145299
Langvallei	192	165 55 1·29	4·6768816
Boomplaats	188	351 53 7·86	4·7289340

BETHEL PELLA.

Station No. 190.

	°	′	″
Latitude	28	1	26·458.
Longitude	25	8	21·507.
Height above M.S.L.	3985·5 feet.		

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Schoonheid	191	170 21 40·36	4·8182523
Houtnek	189	248 2 37·09	4·8189386
Winterhoek	187	339 43 32·51	4·6996780

Final Results—*continued.*

SCHOONHEID.

Station No. 191.

	° ′ ″
Latitude	27 50 51·399.
Longitude	25 6 20·178.
Height above M.S.L.	4116·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kopje Enkel	194	175 24 52·90	4·8418201
Never Mind	193	202 30 44·50	4·7468724
Langvallei	192	263 46 28·24	4·7845374
Houtnek	189	298 45 8·11	4·9145299
Bethel Pella	190	350 22 37·19	4·8132523

LANGVALLEI.

Station No. 192.

	° ′ ″
Latitude	27 49 45·544.
Longitude	25 17 34·333.
Height above M.S.L.	4145·8 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Schoonheid	191	83 41 8·43	4·7845374
Never Mind	193	138 52 9·95	4·7754450
Kameelpan I	195	152 8 48·26	4·9048509
Houtnek	189	345 56 1·54	4·6768816

NEVER MIND.

Station No. 193.

	° ′ ″
Latitude	27 42 20·619.
Longitude	25 10 17·993.
Height above M.S.L.	4223·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Schoonheid	191	22 28 53·67	4·7468724
Kopje Enkel	194	123 14 49·67	4·5080279
Kameelpan I	195	183 45 59·47	4·4176700
Langvallei	192	318 55 33·23	4·7754450

FINAL RESULTS—*continued.*

KOPJE ENKEL.

Station No. 194.

	° ′ ″
Latitude	27 39 25·645.
Longitude	25 5 18·417.
Height above M.S.L.	4315·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Smitskraal	196	167 59 2·18	4·6995477
Nooitgedacht II	197	196 26 59·58	4·7993821
Kameelpan I	195	253 37 12·40	4·4753849
Never Mind	193	303 17 8·84	4·5080279
Schoonheid	191	355 25 21·66	4·8418201

KAMEELPAN I.

Station No. 195.

	° ′ ″
Latitude	27 38 2·111.
Longitude	25 10 37·100.
Height above M.S.L.	4322·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Never Mind	193	3 45 50·60	4·4176700
Kopje Enkel	194	73 34 44·53	4·4753849
Smitskraal	196	136 0 25·25	4·7506427
Nooitgedacht II	197	168 12 9·38	4·7252241
Langvallei	192	332 12 2·41	4·9048509

SMITSKRAAL.

Station No. 196.

	° ′ ″
Latitude	27 31 20·707.
Longitude	25 3 22·652.
Height above M.S.L.	4418·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Amsterdam	198	177 13 8·73	4·1105018
Nooitgedacht II	197	247 56 56·95	4·4842838
Kameelpan I	195	316 3 46·38	4·7506427
Kopje Enkel	194	347 59 55·79	4·6995477

FINAL RESULTS—*continued.*

NOOITGEDACHT II.

Station No. 197.

	° ′ ″
Latitude	27 29 27·221.
Longitude	25 8 36·521.
Height above M.S.L.	4427·4 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Kopje Enkel	194	16 25 27·88	4·7993821
Smitskraal	196	67 54 31·99	4·4842838
Amsterdam	198	92 47 49·63	4·4613352
Klipkuil	199	153 17 13·33	4·9394719
Doornhoek	200	215 8 24·65	4·7055230
Kameelpan I	195	348 13 5·12	4·7252241

AMSTERDAM.

Station No. 198.

	° ′ ″
Latitude	27 29 13·139.
Longitude...	25 3 15·705.
Height above M.S.L.	4425·0 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Klipkuil	199	172 25 9·11	4·8863459
Doornhoek	200	285 26 6·22	4·8488190
Nooitgedacht II	197	272 50 17·71	4·4613352
Smitskraal	196	357 13 11·94	4·1105018

KLIPKUIL.

Station No. 199.

	° ′ ″
Latitude	27 16 37·521.
Longitude...	25 1 23·170.
Height above M.S.L.	4411·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Morgenzon	202	233 53 32·85	4·9749647
Doornhoek..	200	297 58 13·67	4·8882749
Nooitgedacht II	197	333 20 32·64	4·9394719
Amsterdam	198	352 26 0·86	4·8863459

Final Results—*continued.*

DOORNHOEK.

Station No. 200.

	° ′ ″
Latitude	27 22 36·061.
Longitude...	25 14 0·589.
Height above M.S.L.	4497·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Nooitgedacht II	197	35 5 55·34	4·7055280
Amsterdam	198	55 21 9·12	4·8488190
Klipkuil	199	117 52 25·97	4·8882749
Morgenzon	202	184 52 0·46	4·9649100
Holpan	201	225 22 53·72	4·8216085

HOLPAN.

Station No. 201.

	° ′ ″
Latitude	27 14 54·527.
Longitude...	25 22 43·558.
Height above M.S.L.	4530·9 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Doornhoek	200	45 18 53·76	4·8216085
Morgenzon	202	138 57 6·07	4·7784602
Panfontein	203	226 40 51·71	4·2828474

MORGENZON.

Station No. 202.

	° ′ ″
Latitude	27 7 25·908.
Longitude...	25 15 27·193.
Height above M.S.L.	4635·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Doornhoek	200	4 51 20·81	4·9649100
Klipkuil	199	53 47 6·54	4·9749647
Strappan	205	211 33 43·42	4·9636044
Makouwskop	204	257 15 9·28	4·9740451
Panfontein	203	301 5 31·56	4·7945133
Holpan	201	319 0 25·43	4·7784602

FINAL RESULTS—*continued.*

PANFONTEIN.

Station No. 203.

	° ′ ″
Latitude	27 12 44·194.
Longitude...	25 25 18·110.
Height above M.S.L.	4571·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Holpan	201	46 39 40·99	4·2828474
Morgenzon	202	121 1 1·75	4·7945133
Makouwskop	204	215 57 29·07	4·8161694

MAKOUWSKOP.

Station No. 204.

	° ′ ″
Latitude	27 3 59·044.
Longitude	25 32 23·468.
Height above M.S.L.	4526·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Linos in English Feet.
		° ′ ″	
Panfontein	203	35 54 15·04	4·8161694
Morgenzon	202	77 7 26·35	4·9740451
Strappan	205	142 40 58·84	4·8584161
Doornbult III	206	199 50 40·46	4·5763841

STRAPPAN.

Station No. 205.

	° ′ ″
Latitude	26 54 30·314.
Longitude	25 24 20·135.
Height above M.S.L.	4449·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ′	
Morgenzon	202	31 34 41·38	4·9636044
Riet Pan	208	226 22 0·38	4·5767720
Rosalie	207	285 36 0·86	4·7652023
Doornbult III	206	291 15 47·56	4·7829221
Makouwskop	204	322 44 38·17	4·8584161

FINAL RESULTS—*continued.*

DOORNBULT III.

Station No. 206.	° ′ ″
Latitude	26 58 7·802.
Longitude	25 34 44·922.
Height above M.S.L.	4556·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Makouwskop	204	19 49 36·20	4·5763841
Strappan	205	111 11 4·51	4·7829221
Rosalie	207	175 56 26·95	3·8030067

ROSALIE.

Station No. 207.	° ′ ″
Latitude	26 57 5·039.
Longitude	25 34 39·952.
Height above M.S.L.	4548·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Strappan	205	105 31 20·15	4·7652023
Rietpan	208	145 18 43·65	4·7047341
Doornbult II	209	200 11 25·34	4·7941131
Simonsvlei	210	254 23 10·71	4·4728844
Doornbult III	206	355 56 29·21	3·8030067

RIETPAN.

Station No. 208.	° ′ ″
Latitude	26 50 12·332.
Longitude	25 29 21·642.
Height above M.S.L.	4437·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Strappan	205	46 19 44·10	4·5767720
Doornbult II	209	251 37 10·62	4·7245746
Rosalie	207	325 21 7·63	4·7047341

Final Results—*continued.*

DOORNBULT II.

Station No. 209.

	° ′ ″
Latitude	26 47 26·403.
Longitude	25 38 37·012.
Height above M.S.L.	4542·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Rosalie	207	20 9 38·19	4·7941131
Rietpan	208	71 33 0·10	4·7245746
Boschpan	212	250 12 49·71	4·5688763
Zwart's Rust	211	305 54 7·09	4·7648028
Simonsvlei	210	351 55 24·08	4·7069434

SIMONSVLEI.

Station No. 210.

	° ′ ″
Latitude	26 55 45·751.
Longitude	25 39 56·060.
Height above M.S.L.	4622·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Rosalie	207	74 20 47·49	4·4728844
Doornbult II	209	171 54 48·36	4·7069434
Zwart's Rust	211	247 48 14·14	4·6351968

ZWART'S RUST.

Station No. 211.

	° ′ ″
Latitude	26 53 4·041.
Longitude	25 47 17·494.
Height above M.S.L.	4761·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Simonsvlei	210	67 44 54·38	4·6351968
Doornbult II	209	125 50 12·11	4·7648028
Boschpan	212	165 12 48·44	4·6834722
Karreekuil	213	244 40 54·57	4·7643003

FINAL RESULTS—*continued.*

BOSCHPAN.

Station No. 212.

		° ′ ″
Latitude	... ...	26 45 22·022.
Longitude	... ...	25 45 1·662.
Height above M.S.L.	... ...	4635·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Doornbult II	209	70 9 56·44	4·5688763
Disselboompan	214	221 5 36·45	4·8863127
Karreekuil	213	288 35 42·15	4·8351879
Zwart's Rust	211	345 13 49·73	4·6834722

KARREEKUIL.

Station No. 213.

		° ′ ″
Latitude	... ...	26 48 57·573.
Longitude	... ...	25 56 57·308.
Height above M.S.L.	... ...	4986·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Zwart's Rust	211	64 36 32·69	4·7643008
Boschpan	212	108 30 19·63	4·8351879
Disselboompan	214	169 47 16·66	4·9089838
Driekuil	215	235 7 48·40	4·5591265

DISSELBOOMPAN.

Station No. 214.

		° ′ ″
Latitude	... ...	26 35 47·229.
Longitude	... ...	25 54 18·952.
Height above M.S.L.	... ...	4717·3 feet

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Boschpan	212	41 1 26·26	4·8863127
Makoiespan	217	170 42 29·50	5·0239902
Doornbult I	218	208 37 35·13	5·0601006
Middelbult	216	285 1 29·20	4·8299259
Driekuil	215	323 16 44·88	4·8676407
Karreekuil	213	349 48 27·84	4·9089838

FINAL RESULTS—*continued.*

DRIEKUIL.

Station No. 215.

	° ′ ″
Latitude	26 45 32·301.
Longitude	26 2 25·258.
Height above M.S.L.	5053·6 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Karreekuil	213	55 5 20·61	4·5591265
Disselboompan	214	143 13 6·54	4·8676407
Middelbult	216	186 31 47·91	4·9934237
Leeuwfontein	228	251 25 17·12	4·9160887
Schietfontein	229	304 34 30·44	4·8747113

MIDDELBULT.

Station No. 216.

	° ′ ″
Latitude	26 29 23·104.
Longitude	26 4 28·535.
Height above M.S.L.	4870·9 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Driekuil	215	6 30 52·67	4·9934237
Disselboompan	214	54 56 56·80	4·8299259
Makoiespan	217	132 3 32·78	4·9898968
Doornbult I.	218	179 35 3·88	4·7927907
Leeuwfontein	228	316 55 0·55	4·9912581

MAKOIESPAN.

Station No. 217.

	° ′ ″
Latitude	26 18 34·258.
Longitude	25 51 11·454.
Height above M.S.L.	4686·2 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Bethlehem	219	198 51 56·45	4·7675497
Doornbult I.	218	272 47 37·86	4·8583484
Middelbult	216	312 9 27·18	4·9898968
Disselboompan	214	350 43 53·02	5·0239902

FINAL RESULTS—*continued.*

DOORNBULT I.

Station No. 218.

	° ′ ″
Latitude	26 19 8·491.
Longitude	26 4 23·588.
Height above M.S.L.	4893·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Disselboompan	214	28 38 5·75	5·0601006
Makoiespan	217	92 41 46·72	4·8583484
Bethlehem	219	137 51 10·94	4·8995656
De Paarl	220	157 42 38·25	4·9659661
Houthaal Boomen	221	184 47 7·00	4·9881818
Sypherpan	222	245 18 34·67	4·9363582
Middelbult	216	359 35 6·08	4·7927907

BETHLEHEM.

Station No. 219.

	° ′ ″
Latitude	26 9 25·431.
Longitude	25 54 39·229.
Height above M.S.L.	4840·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Makoiespan	217	18 50 24·61	4·7675497
De Paarl	220	214 18 8·38	4·5094816
Doornbult I.	218	317 55 29·28	4·8995656

DE PAARL.

Station No. 220.

	° ′ ″
Latitude	26 5 0·976.
Longitude	25 57 58·971.
Height above M.S.L.	4970·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bethlehem	219	34 16 40·45	4·5094816
Polfontein	225	126 8 14·68	4·5251208
Malopo's Oog	224	195 33 41·87	4·9184084
Welvediend	228	245 29 19·78	4·9814257
Houthaal Boomen	221	270 12 1·57	4·6255412
Doornbult I.	218	337 45 28·07	4·9659661

HOUTHAAL BOOMEN.

Station No. 221.

	° ′ ″
Latitude	26 5 2·232.
Longitude	26 5 42·032
Height above M.S.L.	4957·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Doornbult I.	218	4 46 32·37	4·9331818
De Paarl	220	90 8 37·97	4·6255412
Welvediend	223	224 51 49·28	4·7010562
Sypherpan	222	304 33 10·51	4·9376627

SYPHERPAN.

Station No. 222.

	° ′ ″
Latitude	26 13 9·315.
Longitude	26 18 44·642.
Height above M.S.L.	4992·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Doornbult I	218	65 7 13·58	4·9368582
Houthaal Boomen	221	124 32 25·58	4·9376627
Welvediend	223	157 0 26·63	4·9642780

WELVEDIEND.

Station No. 223.

	° ′ ″
Latitude	25 59 9·378.
Longitude	26 12 10·401.
Height above M.S.L.	5036·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Houthaal Boomen	221	44 48 58·82	4·7010562
De Paarl	220	65 23 6·02	4·9814257
Malopo's Oog	224	127 52 11·85	4·8493289
Sypherpan..	222	337 3 20·09	4·9642780

MALOPO'S OOG.

Station No. 224.

	° ′ ″
Latitude	25 51 59·233.
Longitude	26 1 59·565.
Height above M.S.L.	4999·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
De Paarl	220	15 31 56·50	4·9134034
Polfontein..	225	39 37 32·63	4·8855946
Grootfontein	226	65 7 46·16	4·7829004
Klippan	227	133 3 12·69	4·9177992
Witkop I	92	180 57 36·85	4·6115370
Welvediend	228	307 56 38·92	4·8493239

POLFONTEIN.

Station No. 225.

	° ′ ″
Latitude	26 1 45·181.
Longitude	25 53 2·339.
Height above M.S.L.	4861·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Grootfontein	226	169 55 8·22	4·5341367
Malopo's Oog	224	219 41 27·69	4·8855946
De Paarl	220	306 10 24·93	4·5251208

GROOTFONTEIN.

Station No. 226.

	° ′ ″
Latitude	25 56 11·577.
Longitude	25 51 56·741.
Height above M.S.L.	4786·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Klippan	227	176 16 47·73	4·9148055
Witkop I	92	220 4 46·60	4·9378790
Malopo's Oog	224	245 12 9·48	4·7829004
Polfontein..	225	349 55 31·96	4·5341367

FINAL RESULTS—*continued.*

KLIPPAN.

Station No. 227.

	° ′ ″
Latitude	25 42 39·215.
Longitude	25 50 58·442.
Height above M.S.L.	4740 4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Vergenoeg	93	223 41 40·36	4·8303715
Witkop I	92	284 24 24·62	4·8001619
Malopo's Oog	224	313 8 0·81	4·9177992
Grootfontein	226	356 17 18·13	4·9148055

LEEUWFONTEIN.

Station No. 228.

	° ′ ″
Latitude	26 41 11·502.
Longitude	26 16 46·546.
Height above M.S.L.	5372·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Schietfontein	229	18 19 10·26	4·8495426
Driekuil	215	71 18 49·82	4·9160387
Middelbult	216	136 49 30·23	4·9912581
Rhenosterberg Hoek	230	313 16 2·97	4·9060046

SCHIETFONTEIN.

Station No. 229.

	° ′ ″
Latitude	26 52 33·022.
Longitude	26 13 46·633.
Height above M.S.L.	5195·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Driekuil	215	124 29 28·04	4·8747118
Leeuwfontein	228	198 20 31·38	4·8495426
Rhenosterberg Hoek	230	259 48 28·21	4·8817582
Doornplaats	231	307 25 21·61	4·9448685

Final Results—*continued.*

RHENOSTERBERG HOEK.

Station No. 230.

	° ′ ″
Latitude	26 50 17·797.
Longitude	26 27 33·931.
Height above M.S.L.	5068·9 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Doornplaats	231	4 9 5·21	4·8279892
Schietfontein	229	79 37 14·46	4·8817532
Leeuwfontein	228	138 11 11·46	4·9060046
Klerksdorp	232	281 2 0·16	4·8666362

DOORNPLAATS.

Station No. 231.

	° ′ ″
Latitude	27 1 22·511.
Longitude	26 26 40·064.
Height above M.S.L.	4515·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Schietfontein	229	127 19 31·00	4·9448685
Rhenosterberg Hoek	230	184 9 29·61	4·8279892
Klerksdorp	232	235 28 14·08	4·9710878
Vlaklaagte	233	316 8 12·00	4·8699601

KLERKSDORP.

Station No. 232.

	° ′ ″
Latitude	26 52 36·593.
Longitude	26 40 51·211.
Height above M.S.L.	4456·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Vlaklaagte	233	13 28 10·68	5·0395575
Doornplaats	231	55 21 48·28	4·9710878
Rhenosterberg Hoek	230	100 55 59·97	4·8666362
Paradijs	234	304 24 15·55	4·9098886

FINAL RESULTS—*continued.*

VLAKLAAGTE.

Station No. 233.

	° ′ ″
Latitude	27 10 11·455.
Longitude	26 36 8·732.
Height above M.S.L.	4398·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Nooitverwacht	176	0 3 18·94	5·0797078
Doornplaats	231	186 3 52·98	4·8699601
Klerksdorp	232	193 30 18·98	5·0395575
Paradijs	234	236 48 54·91	5·0438915
Bovenlands Plaats	235	297 32 24·82	4·9525343

PARADIJS.

Station No. 234.

	° ′ ″
Latitude	27 0 10·724.
Longitude	26 53 12·334.
Height above M.S.L.	4721·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Bovenlands Plaats	235	7 11 23·99	5·0121737
Vlaklaagte	233	56 41 8·83	5·0438915
Klerksdorp	232	124 18 39·78	4·9098886

BOVENLANDS PLAATS.

Station No. 235.

	° ′ ″
Latitude	27 17 1·171.
Longitude	26 50 49·680.
Height above M.S.L.	4542·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Nooitverwacht	176	45 12 59·93	5·0489714
Vlaklaagte	233	117 25 41·76	4·9525343
Paradijs	234	187 12 29·06	5·0121737
Rhenosterkop II.	105	294 48 15·44	5·0817729

FINAL RESULTS—*continued.*

MOUNT ANDERSON.

Station No. 236.

	° ′ ″
Latitude	25 4 55·944.
Longitude	30 39 0·335.
Height above M.S.L.	7488·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Verloren Vlei	71	63 7 12·26	5·3147838
Thama Koosh	237	123 0 25·21	5·3762576
Manoutsa	238	181 29 55·01	5·3674112
Tafel Kop (D.K.)	70	353 30 33·68	5·3819130

THAMA KOOSH.

Station No. 237.

	° ′ ″
Latitude	24 43 28·174.
Longitude	30 2 57·388.
Height above M.S.L.	6330·0 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Portugal	240	126 41 8·39	5·5247512
Iron Crown	239	172 36 8·36	5·4249500
Manoutsa	238	243 32 46·70	5·3618672
Mount Anderson	236	303 15 36·01	5·3762576
Verloren Vlei	71	356 19 29·49	5·3491011

MANOUTSA.

Station No. 238.

	° ′ ″
Latitude	24 26 28·215.
Longitude	30 40 6·278.
Height above M.S.L.	5954·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Mount Anderson	236	1 29 27·39	5·3674112
Thama Koosh	237	63 17 19·46	5·3618672
Iron Crown	239	123 37 42·15	5·4614690

FINAL RESULTS—*continued.*

IRON CROWN.

Station No. 239.

	° ′ ″
Latitude	23 59 54·293.
Longitude	29 56 48·020.
Height above M.S.L.	6963·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Portugal	240	74 48 4·40	5·3851465
Schnell's Kop	241	180 53 20·80	4·8689928
Manoutsa	238	303 55 28·07	5·4614690
Thama Koosh	237	352 33 40·73	5·4249500

PORTUGAL.

Station No. 240.

	° ′ ″
Latitude	24 10 18·996
Longitude	29 14 38·581.
Height above M.S.L.	6573·2 feet

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Matala	242	150 44 31·79	5·2110564
Schnell's Kop	241	240 7 57·82	5·4349250
Iron Crown	239	255 5 16·66	5·3851465
Thama Koosh	237	307 1 8·66	5·5247512

SCHNELL'S KOP.

Station No. 241.

	° ′ ″
Latitude	23 47 50·004.
Longitude	29 57 0·235.
Height above M.S.L.	6228·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Iron Crown	239	0 53 15·85	4·8689928
Portugal	240	59 50 44·64	5·4349250
Matala	242	90 54 20·19	5·4993502
Loskop II	243	118 35 51·02	5·3722968
Lejuma	248	148 1 16·41	5·5195814

FINAL RESULTS—*continued.*

MATALA.

Station No. 242.

	° ′ ″
Latitude	23 46 50·161.
Longitude	29 0 21·425.
Height above M.S.L.	5813·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Blaauwberg	247	178 42 30·30	5·4116154
Kameelkop	244	211 21 48·01	5·1380967
Loskop II	243	225 38 30·54	5·1851681
North End of Base	246	235 0 8·49	5·1289855
Schnell's Kop	241	271 17 11·20	5·4993502
South end of Base	245	290 49 57·74	4·9017746
Portugal	240	330 50 20·11	5·2119564

LOSKOP II.

Station No. 243.

	° ′ ″
Latitude	23 29 7·920.
Longitude	29 19 57·708.
Height above M.S.L.	4678·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
South end of Base	245	14 20 38·70	5·1457885
Matala	242	45 30 38·98	5·1851681
Kameel Kop	244	104 59 51·06	4·5948877
Blaauwberg	247	142 28 17·13	5·2784793
Lejuma	248	190 57 24·99	5·2823528
Schnell's Kop	241	298 50 42·29	5·3722968
North end of Base	246	358 27 41·46	4·4757514

KAMEEL KOP.

Station No. 244.

	° ′ ″
Latitude	23 27 26·890.
Longitude	29 13 9·578.
Height above M.S.L.	3968·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Matala	242	31 16 40·24	5·1380967
Loskop II	243	285 2 33·62	4·5948877
North end of Base	246	315 57 59·90	4·7465291
South end of Base	245	358 43 45·61	5·1636069

FINAL RESULTS—*continued.*

SOUTH END OF HOUTS RIVER BASE.

Station No. 245.

	° ′ ″
Latitude	23 51 30·617.
Longitude	29 13 44·393.
Height above M.S.L.	4658·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Matala	242	110 44 38·45	4·9017746
Kameel Kop	244	173 48 31·64	5·1636069
Loskop II	248	194 28 8·59	5·1457885
North end of Base	246	198 35 52·09	5·0469931

NORTH END OF HOUTS RIVER BASE.

Station No. 246.

	° ′ ″
Latitude	23 34 4·122.
Longitude	29 20 6·338.
Height above M.S.L.	3707·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
South end of Base	245	18 33 18·49	5·0469931
Matala	242	54 52 12·70	5·1289855
Kameelkop	244	135 55 13·68	4·7465291
Loskop II.	248	178 27 38·02	4·4757514

BLAAUWBERG.

Station No. 247.

	° ′ ″
Latitude	23 4 14·495.
Longitude	28 59 19·155.
Height above M.S.L.	6709·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Dwarsberg	249	139 46 8·04	5·1741849
Pont	250	191 14 41·70	5·4808186
Lejuma	243	263 34 8·40	5·1784698
Loskop II	248	322 36 26·62	5·2784798
Matala	242	358 42 55·05	5·4116154

FINAL RESULTS—*continued*

LEJUMA.

Station No. 248.

	° ′ ″
Latitude	23 1 26·809.
Longitude	29 25 45·104.
Height above M.S.L.	5713·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Loskop II..	248	10 55 7·84	5·2323523
Blaauwberg	247	83 23 47·50	5·1734698
Dwarsberg	249	111 31 20·18	5·4203880
Pont	250	162 10 12·30	5·4682051
Dogola	251	197 21 49·17	5·4677129
Schnell's Kop	241	328 13 41·47	5·5195314

DWARSBERG.

Station No. 249.

	° ′ ″
Latitude	22 45 23·792.
Longitude	28 42 8·677.
Height above M.S.L.	3541·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Pont	250	220 29 51·28	5·3800622
Lejuma	248	291 48 17·91	5·4203880
Blaauwberg	247	319 52 49·25	5·1741849

PONT.

Station No. 250.

	° ′ ″
Latitude	22 15 13·513.
Longitude	29 9 47·191.
Height above M.S.L.	2072·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Blaauwberg	247	11 10 39·70	5·4808186
Dwarsberg	249	40 19 16·44	5·3800622
Dogola	251	269 58 12·16	5·2494385
Lejuma	248	342 16 21·03	5·4682051

Final Results—*continued.*

DOGOLA.

Station No. 251.

	° ′ ″
Latitude	22 15 9·539.
Longitude	29 41 17·683.
Height above M.S.L.	2910·3 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Lejuma	248	17 15 50·20	5·4677129
Pont	250	89 46 16·23	5·2494385

DASPOORT.

Station No. 252.

	° ′ ″
Latitude	25 43 50·338.
Longitude	28 5 49·500,
Height above M.S.L.	4889·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Cable Hill	84	238 36 38·97	4·4426029
Meintjes Kop	254	274 2 50·91	4·5957967
Muckleneuk	253	290 18 17·44	4·5622402
Klapper Kop	257	295 42 17·85	4·6140169
Zwartkop III	258	342 41 41·95	4·5557521

MUCKLENEUK.

Station No. 253.

	° ′ ″
Latitude	25 45 55·648.
Longitude	28 12 3·878.
Height above M.S.L.	4739·8 feet. 4748·6 „ *

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Daspoort	252	110 15 34·80	4·5622402
Cable, Hill..	84	158 38 7·35	4·4636922
Meintjes Kop	254	207 15 32·64	4·0461295
Koedoespoort	255	240 3 8·60	4·3361652
Camp	256	276 19 7·15	4·1622797

* By Geodetic Levelling.

FINAL RESULTS—*continued.*

MEINTJES KOP.

Station No. 254.

	° ′ ″
Latitude	25 44 17·726.
Longitude	28 12 59·577.
Height above M.S.L.	4722·4 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Muckleneuk	253	27 15 8·44	4·0461295
Daspoort	252	93 59 44·17	4·5957966
Cable Hill	84	137 37 33·60	4·3670815
Koedoespoort	255	266 4 4·26	4·1376297
Camp	256	320 50 50·04	4·1705203

KOEDOESPOORT.

Station No. 255.

	° ′ ″
Latitude	25 44 8·379.
Longitude	28 15 29·349.
Height above M.S.L.	4477·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Camp	256	19 15 41·31	4·1193676
Muckleneuk	253	60 1 39·33	4·3361652
Meintjes Kop	254	86 2 59·22	4·1376297
Cable Hill	84	118 56 7·03	4·5261560

CAMP.

Station No. 256.

	° ′ ″
Latitude	25 46 11·464.
Longitude	28 14 41·851.
Height above M.S.L.	4639·6 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Muckleneuk	253	96 17 58·47	4·1622797
Cable Hill	84	138 51 57·18	4·5806639
Meintjes Kop	254	140 50 5·60	4·1705201
Koedoespoort	255	199 16 1·95	4·1193676

FINAL RESULTS—*continued.*

KLAPPER KOP.

Station No. 257.

		° ′ ″
Latitude	... ...	25 46 46·828.
Longitude	... .	28 12 34·770.
Height above M.S.L.	... ...	5054·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Zwartkop III	258	57 54 36·78	4·4925983
Daspoort	252	115 39 21·75	4·6140169
Cable Hill	84	157 24 19·75	4·5482646
Irene	259	342 26 13·77	4·5367964

ZWARTKOP III.

Station No. 258.

		° ′ ″
Latitude	... ...	25 49 30·338.
Longitude	... ...	28 7 46·538.
Height above M.S.L.	... ...	5038·8 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Daspoort	252	162 40 51·06	4·5557521
Klapper Kop	257	237 56 42·19	4·4925983
Irene	259	298 58 1·76	4·6039979
Brakfontein	260	341 22 35·78	4·5687191

IRENE.

Station No. 259.

		° ′ ″
Latitude	... ...	25 52 11·846.
Longitude	... ...	28 14 28·470.
Height above M.S.L.	... ...	5135·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Oliphantsfontein	261	0 7 36 58	4·4970880
Brakfontein	260	52 54 19·49	4·4988459
Zwartkop III	258	118 55 6·58	4·6039979
Klapper Kop	257	162 25 24·24	4·5367964

FINAL RESULTS—*continued.*

BRAKFONTEIN.

Station No. 260.

	° ′ ″
Latitude	25 55 18·032.
Longitude	28 9 56·102.
Height above M.S.L.	5234·4 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Witpoort	268	59 0 45·09	4·5347506
Zwartkop III	258	161 21 39·24	4·5687191
Irene	259	232 56 18·44	4·4938459
Oliphantsfontein	261	296 58 24·82	4·4438270
Klipfontein	262	356 35 40·07	4·6903127

OLIPHANTSFONTEIN.

Station No. 261.

	° ′ ″
Latitude	25 57 22·938.
Longitude	28 14 27·708.
Height above M.S.L.	5055·1 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Klipfontein	262	31 2 27·12	4·6272845
Brakfontein	260	116 56 26·02	4·4438270
Irene	259	180 7 36·86	4·4970880

KLIPFONTEIN.

Station No. 262.

	° ′ ″
Latitude	26 3 22·641.
Longitude	28 10 28·026.
Height above M.S.L.	5522·7 feet.

Station Observed.	Station No.	Azimuths. ° ′ ″	Log Lengths of Lines in English Feet.
Germiston	265	11 0 30·17	4·6797362
Observatory Hill (Johannesburg) ..	96	34 36 48·21	4·7506204
Driefontein	264	91 24 18·55	4·6697873
Witpoort	268	134 6 13·39	4·6527812
Brakfontein	260	176 35 26·08	4·6903127
Oliphantsfontein	261	211 4 12·21	4·6272845

FINAL RESULTS—*continued.*

WITPOORT.

Station No. 263.

	° ′ ″
Latitude	25 58 12·628.
Longitude	28 4 34·326.
Height above M.S.L.	5045·2 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Driefontein	264	25 39 53·18	4·5241052
Brakfontein	260	289 3 5·87	4·5847506
Klipfontein	262	314 3 48·51	4·6527812

DRIEFONTEIN.

Station No. 264.

	° ′ ″
Latitude	26 3 11·034
Longitude	28 1 55·587
Height above M.S.L.	5164·1 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Witpoort	263	205 41 2·80	4·5241052
Klipfontein	262	271 28 3·63	4·6697873
Germiston	265	322 2 45·34	4·7857133
Observatory Hill (Johannesburg) ..	96	342 48 42·38	4·6966231

GERMISTON.

Station No. 265.

	° ′ ″
Latitude	26 11 7·693
Longitude	28 8 47·764
Height above M.S.L.	5855·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Kliprivierøberg	267	37 10 28·15	4·5860658
Observatory Hill (Johannesburg) ..	96	91 31 53·43	4·3591274
Driefontein	264	141 59 43·38	4·7857133
Klipfontein	262	191 1 14·31	4·6797862
P6 Beacon..	266	346 50 35·98	4·3826612

FINAL RESULTS—*concluded.*

P6 BEACON.

Station No. 266.

	° ′ ″
Latitude	26 14 35·155
Longitude	28 9 41·535
Height above M.S.L.	5502·5 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Klipriviersberg	267	70 52 5·88	4·4747698
Observatory Hill (Johannesburg) ..	96	127 49 46·06	4·5458072
Germiston	265	166 50 12·22	4·3326612

KLIPRIVIERSBERG.

Station No. 267.

	° ′ ″
Latitude	26 16 11·892
Longitude	28 4 31·866
Height above M.S.L.	5939·7 feet.

Station Observed.	Station No.	Azimuths.	Log Lengths of Lines in English Feet.
		° ′ ″	
Observatory Hill (Johannesburg) ..	96	180 50 18·25	4·4960190
Germiston	265	217 12 21·24	4·5860658
P6 Beacon	266	250 54 42·88	4·4747698

END.

INDEX.

NOTE ON ALPHABETICAL INDEX TO STATIONS.

Column 1.—Gives the Names of Stations in alphabetical order.

„ 2.—Gives the reference numbers of Stations.

„ 3.—Gives a letter indicating the Survey in which the Station was observed.

"G" denotes that the point occurs in the Geodetic Survey of Cape Colony and Natal.

"T" denotes that the point occurs in the present Trigonometrical Survey.

Stations at which Astronomical observations of Latitude, Longitude, and Azimuth were made are denoted by ϕ, λ, α, respectively.

„ 4.—Gives the pages in which the Horizontal Angles observed at the Station occur, the corrections applicable to the Observed Angles, and the finally adjusted angles.

„ 5.—Gives the page-reference for the Astronomical observations.

„ 6.—Gives the page-reference for the Final Results at the Station for Latitude, Longitude, Azimuth, Logarithms of the Lengths of the Sides, and Height of Mean Sea Level.

„ 7.—Gives the references necessary for following the discussion of the adjustment of Angles.

The Roman numerals I. to XXVII. denote the Figural Equations (pages 107 to 125) which occur in the adjustment of the complex figures.

"C" denotes that the Station occurs in the adjustment of Circuits. (Pages 125 to 144).

The Roman numerals XVA. to XIXA. denote the Non-Circuit Equations. (Pages 148 to 150.)

ALPHABETICAL INDEX TO STATIONS.

Column (1) Name of Station.	(2) Number of Station.	(3) Mark of Survey.	(4) Observed Angles, Corrections, and Final Angles.	(5) Astronomical Observations.	(6) Final Results.	(7) Figures in which the Stations occur.
			Page	Page	Page	
Aasvogel Berg	127	T φ	78	323–324	404	X, C.
Aasvogel Kop	162	T	78	..	416	XII, XIII, C.
Amsterdam	198	T	81	..	428	XVII, C, XVIIA.
Arrochar	37	G	63	..	374	C.
Baatjes Bult	69	T	67	..	385	II, C.
Baynes	43	G	64, 65	..	376	
Baynes' Hill	39	G	63, 64	..	374	
Bazeia	11	G	60, 61	..	365	C.
Bekruip Kop	3	G	60	..	362	C.
Bele	14	G	60, 61	..	366	
Belfast	74	T	67, 68	..	386	
Belfast Base, North End	78	T φ	68	310	388	
Belfast Base, South End	77	T φ α	68	281–282, 312	387	
Bendearg	130	T φ	74	325	405	C.
Berlin	5	G φ λ α	60	..	363	
Besters Kop	133	G T	74	..	406	C.
Bethel Pella	190	T	80	..	425	C.
Bethlehem	219	T	83	..	435	C.
Biesie Pan	172	T	79	..	419	XIV, C.
Biggarsberg	55	T	65, 66	..	380	C.
Blaauwberg	247	T φ	85, 86	305–306	444	XXII, XXIII.
Blaauwkop	64	T	66, 67	..	383	II.
Blijvooruitzicht	97	T	70	..	394	C.
Boesmans Kop	184	T	80	..	428	C.
Boomplaats	188	T	80	..	425	C.

ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)
Name of Station.	Number of Station.	Mark of Survey.	Observed Angles, Corrections, and Final Angles.	Astronomical Observations.	Final Results.	Figures in which the Stations occur.
			Page	Page	Page	
Bosberg	170	T	79	..	419	C.
Boschjes Pan	186	T	75	..	407	C.
Boschpan	212	T	82	..	433	C.
Boschrand	106	T ϕ a	71, 72	290–292, 317	397	VIII, C.
Boshof Hill	165	T	78	..	417	XII, XIII, C.
Boshofsberg	85	T	69	..	390	C.
Bovenlands Plaats	235	T	84	..	440	C.
Brakfontein	260	T	87	..	449	
Braunzijn Kop	107	T ϕ	71, 72	319	397	VIII, C.
Breakfast Vlei	1	G	60	..	362	C.
Byrne Town	32	G	62, 63	..	372	C.
Cable Hill	84	T	69, 70, 86, 87	..	390	XXIV, XXV, C.
Camp	256	T	86	..	447	XXIV.
Cwecweni	9	G ϕ a	60	300–302, 327	364	C.
Daspoort	252	T	86, 87	..	446	XXV.
De Paarl	220	T	83	..	435	XIX, C, XIXA.
De Put	142	T	75	..	409	C.
Dikhoele	121	T	78	..	402	IX.
Disselboompan	214	T	82, 83	..	433	XVIII, C, XVIIIA.
Distant Bush	154	G	76, 77	..	413	
Dogola	251	T	86	..	446	
Doornbult I	218	T	82, 83	..	435	XVIII, XIX, C, XVIIIA, XIXA.
Doornbult II	209	T	82	..	432	C.
Doornbult III	206	T	82	..	431	C.
Doornboom	153	G	76, 77	..	413	

ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)
Name of Station.	Number of Station.	Mark of Survey.	Observed Angles, Corrections, and Final Angles.	Astronomical Observations.	Final Results.	Figures in which the Stations occur.
			Page	Page	Page	
Doornhoek	200	T	81	..	429	XVII, C, XVIIA.
Doornkop	104	T	71, 72	..	396	VIII, C.
Doornplaats	281	T	84	..	439	C.
Drakensberg	58	G T	66, 80	..	381	C.
Drie Baden	141	T	75	..	409	XI, C.
Driefontein	264	T	87	..	450	XXVI.
Driekuil	215	T ϕ α	82, 84	287–289, 314	434	C.
Du Plessis Dam	169	T	78	..	418	C.
Dwarsberg	249	T	86	..	445	XXIII.
Eckmond	146	G	75, 76	..	410	C.
Elandsberg II	132	G	74, 75	..	406	C.
Elandsberg III	63	T	66, 67	..	383	II, C.
Elandskop I	100	T	70	..	395	C.
Elandskop II	111	T	70	..	399	VIII, C
Enzelberg	91	T	69	..	392	V, VI, C.
Fauresmith Hill	138	T	75	..	408	XI, C.
Flag Point	160	G	77	..	415	
Gowengana	16	G	61	..	367	
Gemsbokberg	182	T ϕ	80	315	423	C.
Germiston	265	T	87, 88	..	450	XXVI, XXVII.
Gobo Gobo	124	T	73	..	403	IX, X, C.
Gonubie	4	G	60	..	363	C.
Greenkop	38	G	63, 64	..	374	
Grootfontein	226	T	83	..	437	XX, C.
Groot Riet Vlei	79	T	67, 68	..	388	IV, C.

ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1) Name of Station.	(2) Number of Station.	(3) Mark of Survey.	(4) Observed Angles, Corrections, and Final Angles.	(5) Astronomical Observations.	(6) Final Results.	(7) Figures in which the Stations occur.
			Page	Page	Page	
Helvelyn	129	T φ	74	324	405	C.
Hermitage	181	T φ	80	318	422	C.
Hlamimpesi Berg	62	T	66, 67	..	382	I, II, C.
Hluku	26	G	62	..	370	
Hogsback	2	G	60	..	362	C.
Holpan	201	T	81	..	429	C.
Houthaal Boomen	221	T	83	..	436	XIX, C, XIXA.
Houtnek	189	T	80	..	425	C.
Houts River Base, North End	246	T φ	85	307–308	444	XXI.
Houts River Base, South End	245	T φ α	85	275–278, 309	444	XXI.
Ingeli	27	G	62	..	370	
Inhluzan	33	G	63	..	372	C.
Inkwelo	59	G T φ	66, 80	315–316	381	I, C.
Insizwa	20	G	61, 62	..	368	C.
Irene	259	T	87	..	448	
Iron Crown	239	T	85	..	442	
Jammersberg	120	T	72, 73, 74	..	402	IX, X, C.
Job's Kop	54	T	65, 66	..	379	C.
Joostenberg	144	G	75	..	410	
Jumbla	21	G	62	..	368	C.
Kaalkop I	89	T	69	..	391	V, C.
Kaalkop II	180	T φ	79, 80	316	422	C.
Kaffir Kop	112	T	70, 79	..	399	VIII, C.
Kameelpan I	195	T	81	..	427	XV, XVI, C, XVA, XVIA.
Kameelpan II	167	T	78, 80	..	418	XIII, C.

Alphabetical Index to Stations—*continued.*

Column (1) Name of Station.	(2) Number of Station.	(3) Mark of Survey.	(4) Observed Angles, Corrections, and Final Angles.	(5) Astronomical Observations.	(6) Final Results.	(7) Figures in which the Stations occur.
			Page	Page	Page	
Kameelkop	244	T	85	..	443	XXI.
Karreelaagte	168	T	78, 79	..	418	C.
Karreekuil	213	T	82	..	433	C.
Kimberley Base, North End	159	G	77	..	415	
Kimberley Base, South End	161	G	76, 77	..	416	
Kimberley Base, Measured End	158	G	77	..	414	
Kimberley Hill	151	G	76	..	412	C.
Kimberley, Longitude Point	157	G ϕ λ α	77	..	414	
Klapperkop	257	T	87	..	448	
Klerksdorp	232	T	84	..	439	C.
Klipfontein	262	T	87	..	449	XXVI.
Klipkuil	199	T	81	..	428	XVII, C, XVIIA.
Klippan	227	T	83	..	438	XX, C.
Kliprivierberg	267	T	88	..	451	XXVII.
Koedoespoort	255	T	86, 87	..	447	XXIV.
Koesberg	126	T	73	..	404	X, C.
Kokstad	28	G λ	62	..	371	
Kolskop	147	G	76	..	411	C.
Kopje Enkel	194	T	81	..	427	XV, XVI, C, XVA, XVIA.
Kraals	46	G	65	..	377	
Kroonstad Base, West End	108	T	71, 72	..	398	VIII.
Kroonstad Base, East End	109	T	71	..	398	VIII.
Ladykok	19	G	61, 62	..	368	C.
Langberg I	61	T	66	..	382	I, II, C.
Langberg II	177	T	79	..	421	C.

Alphabetical Index to Stations—*continued.*

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)
Name of Station.	Number of Station.	Mark of Survey.	Observed Angles, Corrections, and Final Angles.	Astronomical Observations.	Final Results.	Figures in which the Stations occur.
			Page	Page	Page	
Langekloof	75	T φ	68	311	387	III, IV.
Langvallei	192	T	80, 81	..	426	XV, C, XVA.
Leeuwberg	145	G	75, 76	..	410	C.
Leeuwlaagte	186	T	80	..	424	C.
Leeuwfontein	228	T	84	..	438	C.
Lejuma	248	T φ	86	305	445	XXII, XXIII,
Lemoenfontein	125	T	74	..	403	X, C
Liebenberg Stroom	103	T	70, 71	..	396	VIII, C.
Lokshoek	139	T	75	..	408	XI, C.
Loskop I	143	G	75, 76	..	409	C.
Loskop II	243	T φ	85, 86	306–307	443	XXI, XXII.
Lubisi	8	G T φ	60, 74	326–327	364	C.
Luipers Rand	140	T	75	..	408	XI, C.
Mabehlan	30	G	62	..	371	C.
Mabula	117	T	72, 73	..	401	X, C.
Machache	116	T	72	..	400	X, C.
Mackenzie's	45	G	64, 65	..	376	
Makoies Pan	217	T	82, 83	..	434	XVIII, C, XVIIIA.
Makouws Kop	204	T	82	..	430	C.
Malopo's Oog	224	T	83	..	437	XX, C.
Malowe	25	G	62	..	370	C.
Manoutsa	238	T	84, 85	..	441	
Maré's Kop	76	T φ	68	310	387	III, IV.
Marwaqa	31	G	62, 63	..	372	C.
Matala	242	T	85	..	443	XXI, XXII.

ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)
Name of Station.	Number of Station.	Mark of Survey.	Observed Angles, Corrections, and Final Angles.	Astronomical Observations.	Final Results.	Figures in which the Stations occur.
			Page	Page	Page	
Mbulu	7	G	60	..	364	C.
Meintjes Kop	254	T ϕ	86, 87	312	447	XXIV, XXV.
Middelbult	216	T	82, 83, 84	..	434	XVIII, C, XVIIIA.
Mijnhardt's Rust	113	T	72	..	399	C.
Moller Pile	148	G	76	..	411	C.
Morgenzon	202	T	81, 82	..	429	C.
Morton's Hill	40	G	63, 64	..	375	
Morton's Kraals	44	G	64, 65	..	376	
Mount Anderson	236	T	84	..	441	
Mount Currie	22	G	62	..	369	C.
Mount Gilboa	36	G	63	..	373	
Muckleneuk	253	T ϕ	86, 87	313	446	XXIV, XXV.
Mungunung	23	G	62	..	369	
Natal Base, North End	50	G	65	..	378	
Natal Base, South End	49	G	65		378	
Ncolora	13	G	60, 61	..	366	C.
Never Mind	193	T	81	..	426	XV, C, XVA.
Newcastle	58A	G $\phi \lambda \alpha$	66	..	381	
Noma Hill	56	G	66	..	380	C.
Nooitgedacht I	86	T	69, 70	..	390	C.
Nooitgedacht II	197	T	81	..	428	XVI, XVII, C, XVIA, XVIIA.
Nooitverwacht	176	T	79, 84	..	421	C.
Nquadu	15	G	61	..	366	
Nquashu	18	G	61	..	367	C.
Nthabankulu	60	T	66	..	382	I, C.

ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1) Name of Station.	(2) Number of Station.	(3) Mark of Survey.	(4) Observed Angles, Corrections, and Final Angles.	(5) Astronomical Observations.	(6) Final Results.	(7) Figures in which the Stations occur.
			Page	Page	Page	
Nthodimonate	128	T	74	..	404	C.
Observatory Hill (Johannesburg)	96	T $\phi\alpha$	70, 87, 88	283–286, 313–314	394	XVI, XVII, C.
Oliphantsfontein	261	T	87	..	449	
Onderbrook..	53	G	65	..	379	C.
Onverwacht	90	T	69	..	392	V, VI, C.
Orange River	184	G T $\phi\alpha$	74, 75, 76	293–295, 321	406	C.
Otto's Bluff	41	G	64	.	375	
Ottoshoop Base, North End	94	T $\phi\alpha$	70	279–280, 311	393	VII.
Ottoshoop Base, South End	95	T	69, 70	..	393	VII.
P6 Beacon	266	T	87, 88	..	451	XXVII.
Paardeberg..	163	T	78	..	416	XII.
Paardekop I	80	T	68, 69	..	388	IV, C.
Paardekop II	98	T	70	..	394	C.
Panfontein	203	T	81, 82	..	430	C.
Panplaats	73	T	67, 68	..	386	IV, C.
Paradijs	234	T	84	..	440	C.
Pilandsberg	87	T	69	..	391	V, C.
Platkop	137	T	75	..	407	XI, C.
Polfontein	225	T	83	..	437	C.
Pont..	250	T	86	..	445	XXIII.
Portugal	240	T	85	..	442	
Quaggafontein	82	T	69	..	389	C.
Rhebokberg	115	T	72	..	400	C.
Rhenosterberg Hoek	230	T	84	..	439	C.
Rhenosterkop I	81	T	68, 69	..	389	IV, C.

ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)
Name of Station.	Number of Station.	Mark of Survey.	Observed Angles, Corrections, and Final Angles.	Astronomical Observations.	Final Results.	Figures in which the Stations occur.
			Page	Page	Page	
Rhenosterkop II	105	T	71, 72, 79	..	397	VIII, C.
Rietfontein	110	T	70, 71	..	398	VIII, C.
Rietpan	208	T	82	..	431	C.
Rondefontein	164	T	78	..	417	XII, C.
Rosalie	207	T	82	..	431	C.
Roundhill	48	G	65	..	377	
Salt Lake	57	G T φ	66	319	380	C.
Sand	155	G	76, 77	..	413	
Schietfontein	229	T	84	..	438	C.
Schnell's Kop	241	T φ	85, 86	308–309	442	XXII.
Scholtz Kop	149	G T	76, 78	..	411	XII, C.
Schoongezicht	173	T φ	79	320	420	XIV, C.
Schoonheid	191	T	80, 81	..	426	XV, C, XVA.
Simonsvlei	210	T	82	..	432	C.
Smitskraal	196	T	81	..	427	XVI, C, XVIA.
Spioenkop (Natal)	35	G	63	..	373	C.
Spionkop	166	T	78	..	417	XIII.
Spitzkop I	65	T	67	..	383	II, C.
Spitzkop II	102	T	70	..	396	VIII, C.
Sterkfontein	67	T	67	..	384	II.
Strappan	205	T	82	..	430	C.
Sypherpan	222	T	83	..	436	XIX, C, XIXA.
Table Mountain	51	G	65	..	378	C.
Tafelkop	88	T	69	..	391	V, C.
Tafelkop (Ermelo)	66	T	67	..	384	II, C.

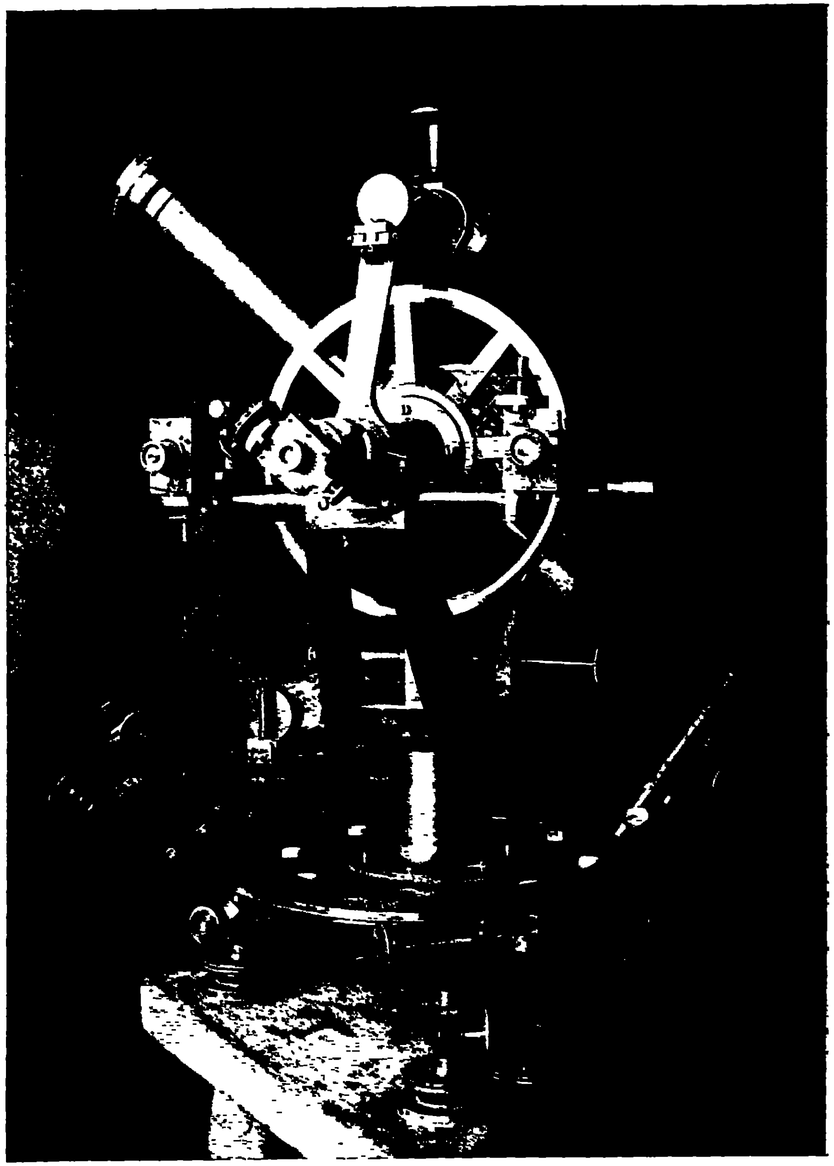
Alphabetical Index to Stations—*continued.*

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)
Name of Station.	Number of Station.	Mark of Survey.	Observed Angles, Corrections, and Final Angles.	Astronomical Observations.	Final Results.	Figures in which the Stations occur.
			Page	Page	Page	
Tafelkop (Duivel's Kantoor)	70	T	67, 84	..	385	II, C.
Tarantal Kop	152	G T	76, 78	..	412	XII, XIII, C.
Thaba Putsua	118	T	72, 73	..	401	X, C.
Thaba Tsueu	119	T	72, 73	..	401	IX, X, C.
Thama Koosh	237	T	84, 85	..	441	
Theron's Kop	174	T ϕ	79	320	420	XIV, C.
Umkolumbu	52	G	65	..	379	C.
Uitkyk	185	T	80	..	424	C.
Umtamvuna	29	G ϕ α	62	..	371	
Umtata	17	G ϕ λ α	61	..	367	
Vaalbank Kop	179	T	79, 80	..	422	C.
Vergenoeg	93	T	69, 70, 83	..	393	VI, VII, C.
Verloren Vlei	71	T	67, 68	..	385	II, IV, C.
Vierfontein	178	T ϕ	79	317	421	C.
View Hill	12	G	60, 61	..	365	C.
Vlakfontein	68	T	67	..	384	II, C.
Vlaklaagte	233	T	84	..	440	C.
Vliegenkraal	101	T	70, 71	..	395	VIII, C.
Warwicker	156	G	77	..	414	
Waschbank Peak	131	T	74	..	405	C.
Waterfall	47	G	65	..	377	
Well Point	160A	G	77	..	415	
Weltevreden	171	T	78, 79	..	419	C.
Welvediend	223	T	83	..	436	XIX, C, XIXA.
Wepener Base, North End	122	T ϕ α	73, 74	296–299, 321–322	402	IX.

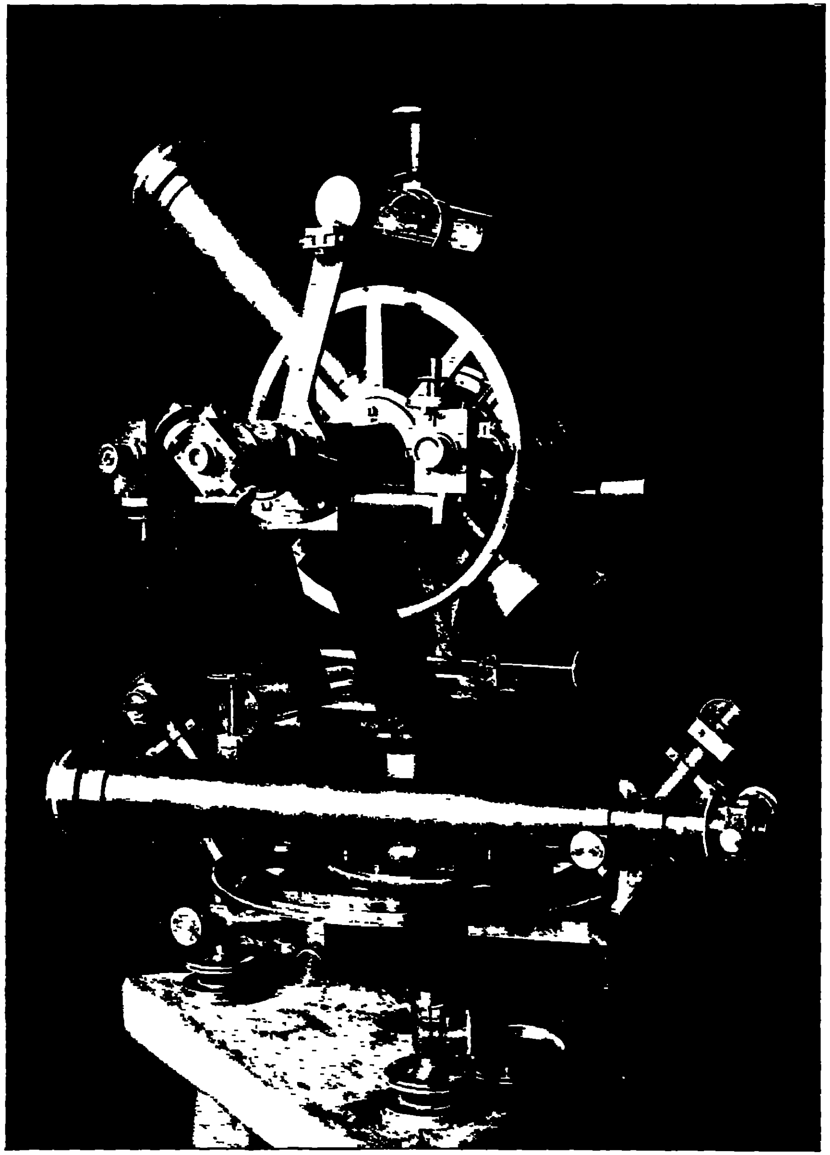
ALPHABETICAL INDEX TO STATIONS—*continued.*

Column (1) Name of Station.	(2) Number of Station.	(3) Mark of Survey.	(4) Observed Angles, Corrections, and Final Angles.	(5) Astronomical Observations.	(6) Final Results	(7) Figures in which the Stations occur.
			Page	Page	Page	
Wepener Base, South End	123	T φ	73, 74	322–323	403	IX.
Windvogelberg	6	G	60	..	363	C.
Winterhoek	187	T	80	..	424	C.
Witpoort	263	T	87	..	450	
Witkop I	92	T	69, 70, 83	..	392	VI, VII, XX, C.
Witkop II	99	T	70	..	395	C.
Wolvedam	150	G	76	..	412	C.
Wonderfontein	72	T	67	..	386	II, C
Wonderkloof	135	T	74, 75	..	407	C.
Xuka	10	G T φ	60, 74	325–326	365	C.
York	42	G	64	..	375	
Zoetvlei	175	T φ	79	318	420	XIV, C.
Zwartberg	24	G	62	..	369	C.
Zwartkloof	83	T	69	..	389	C.
Zwartkop I	34	G φ a	63, 64	..	373	C.
Zwartkop II	183	T	80	..	423	C.
Zwartkop III	258	T	87	..	448	
Zwartkrans	114	T	72	..	400	C.
Zwart's Rust	211	T	82	..	432	C.

PLATE I.

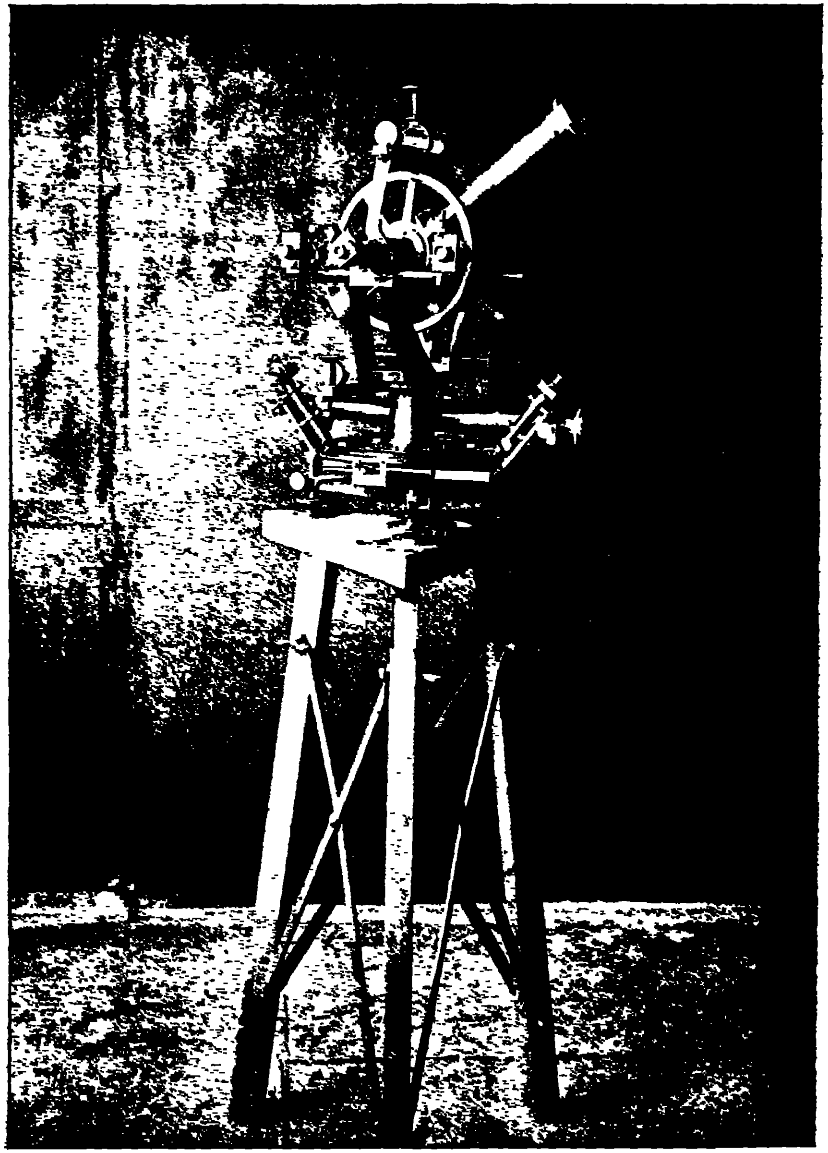


1. REPSOLD THEODOLITE (NEAR VIEW).

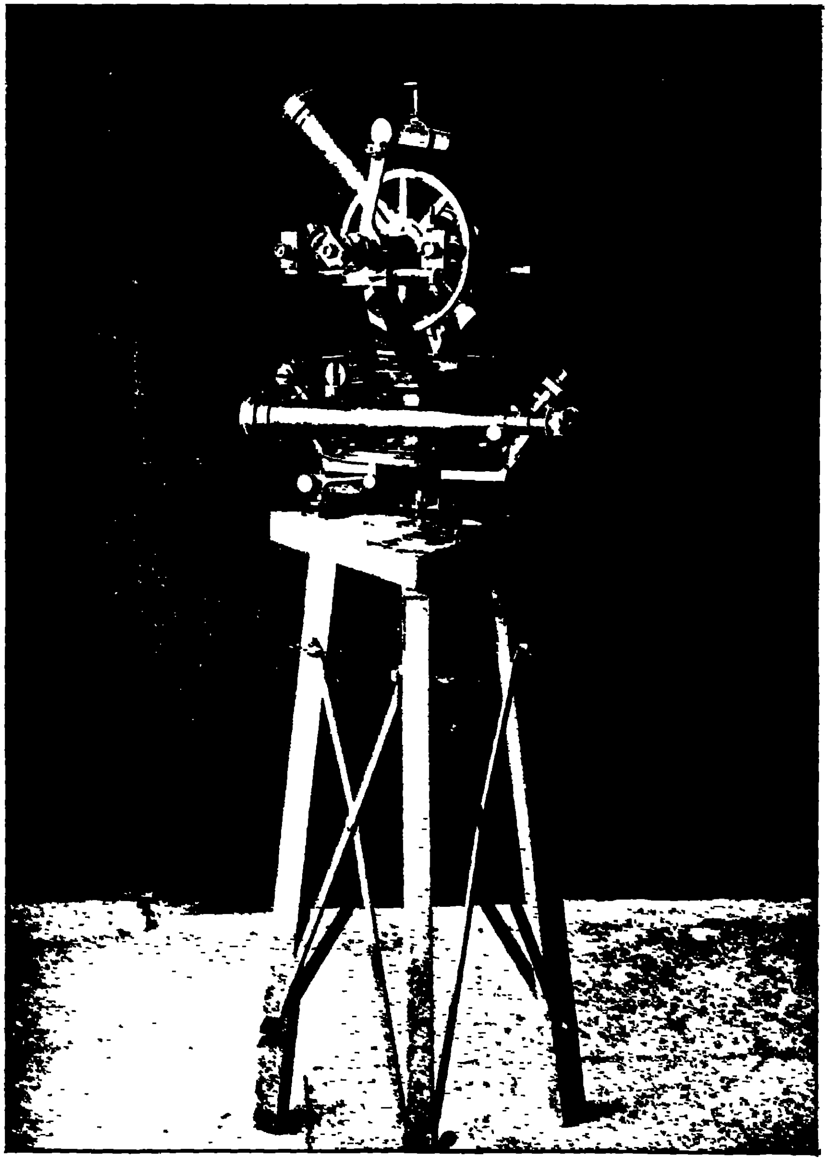


2. DITTO (OTHER SIDE).

PLATE II.

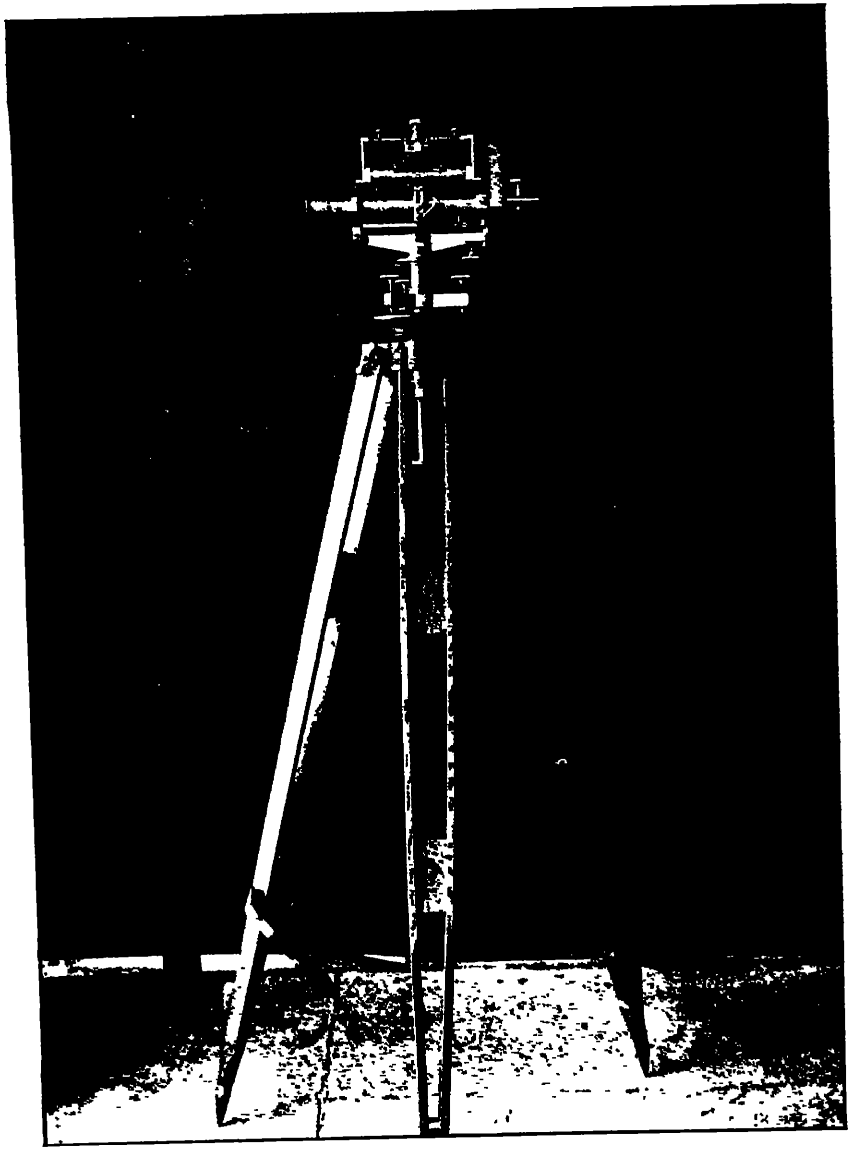


3. REPSOLD THEODOLITE ON ITS PORTABLE STAND.

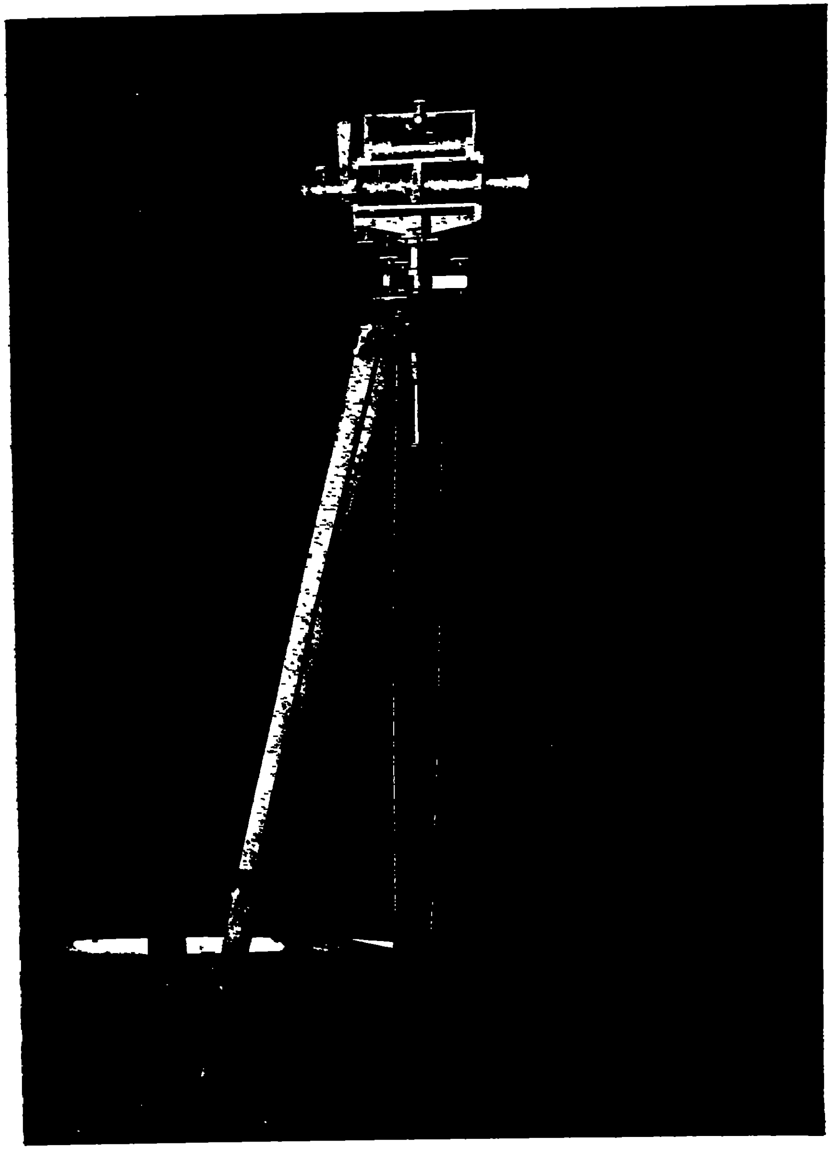


4. DITTO (OTHER SIDE).

PLATE III.

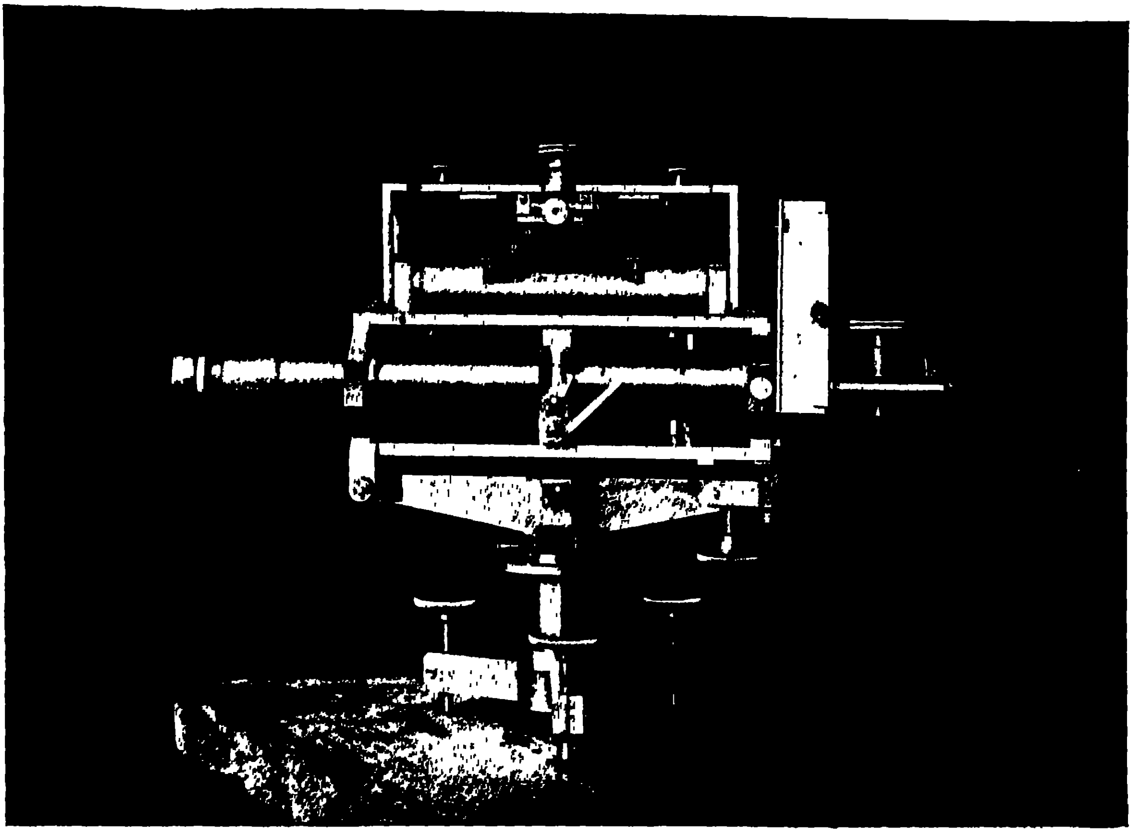


5. LEVELLING INSTRUMENT ON ITS TRIPOD.

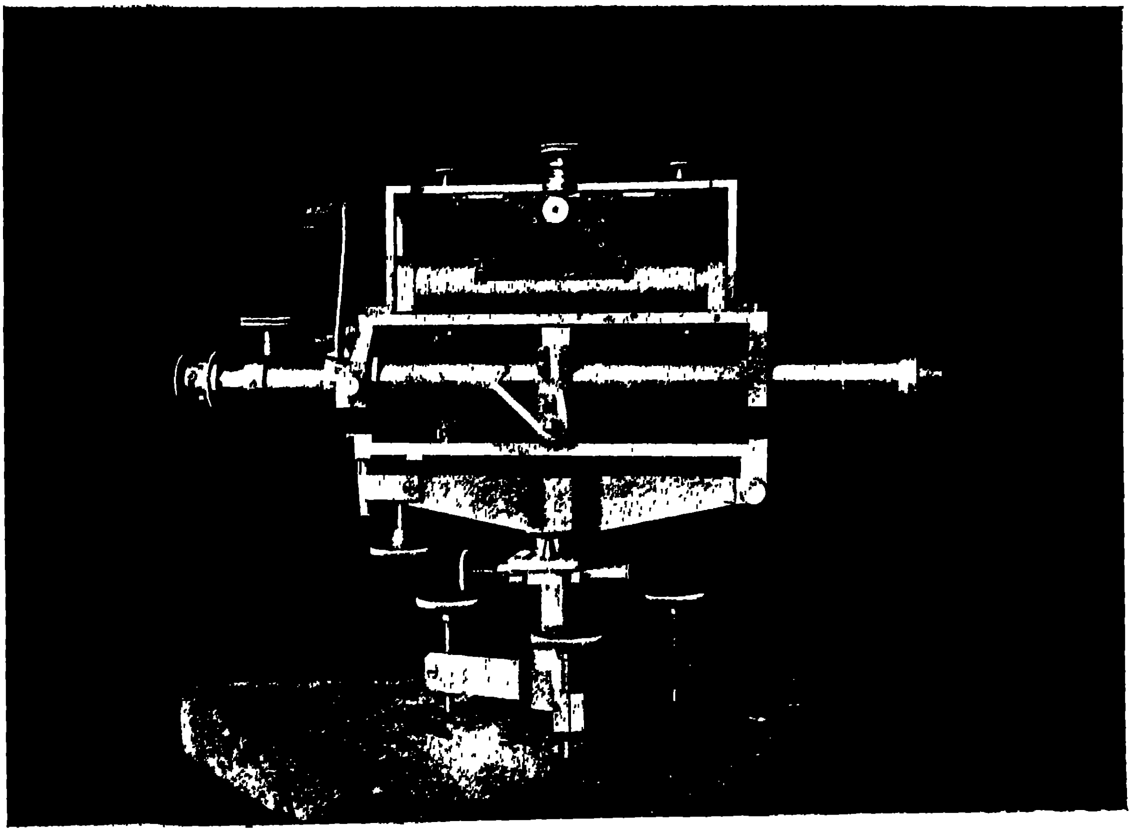


6. DITTO (OTHER SIDE).

PLATE IV.



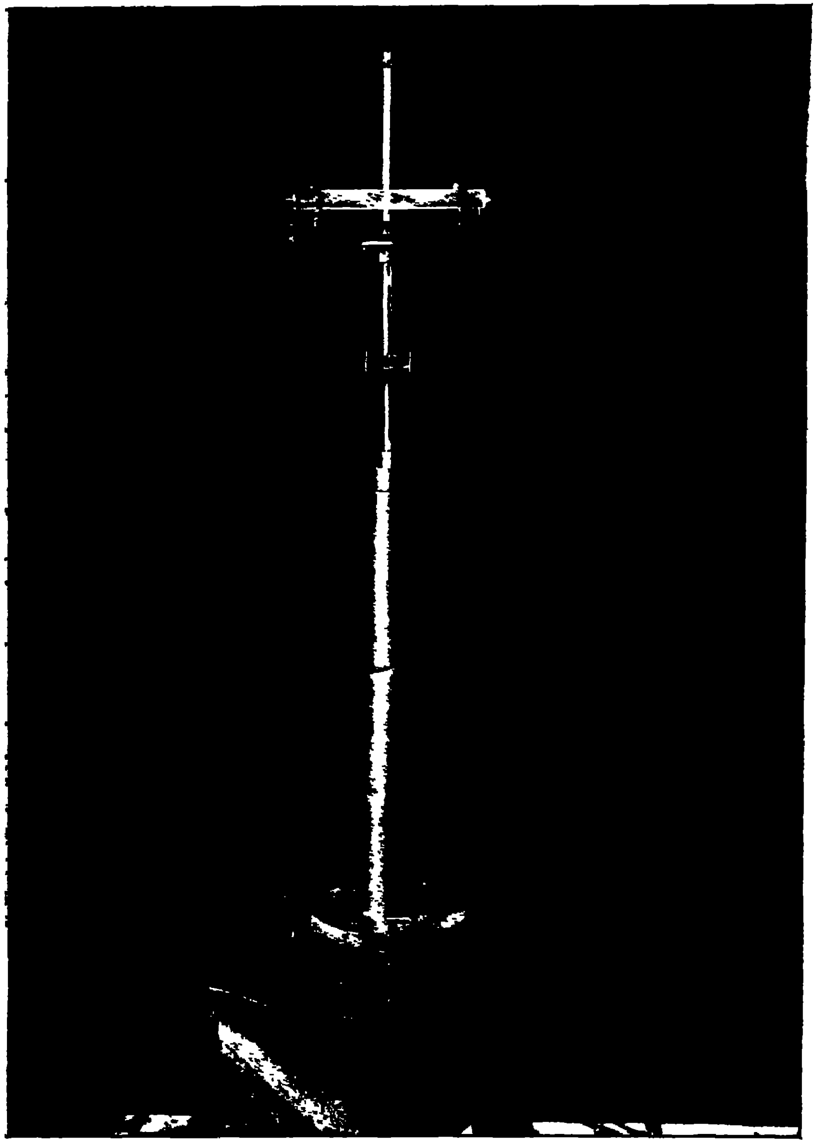
7. LEVELLING INSTRUMENT (NEAR VIEW).



8. DITTO (OTHER SIDE).

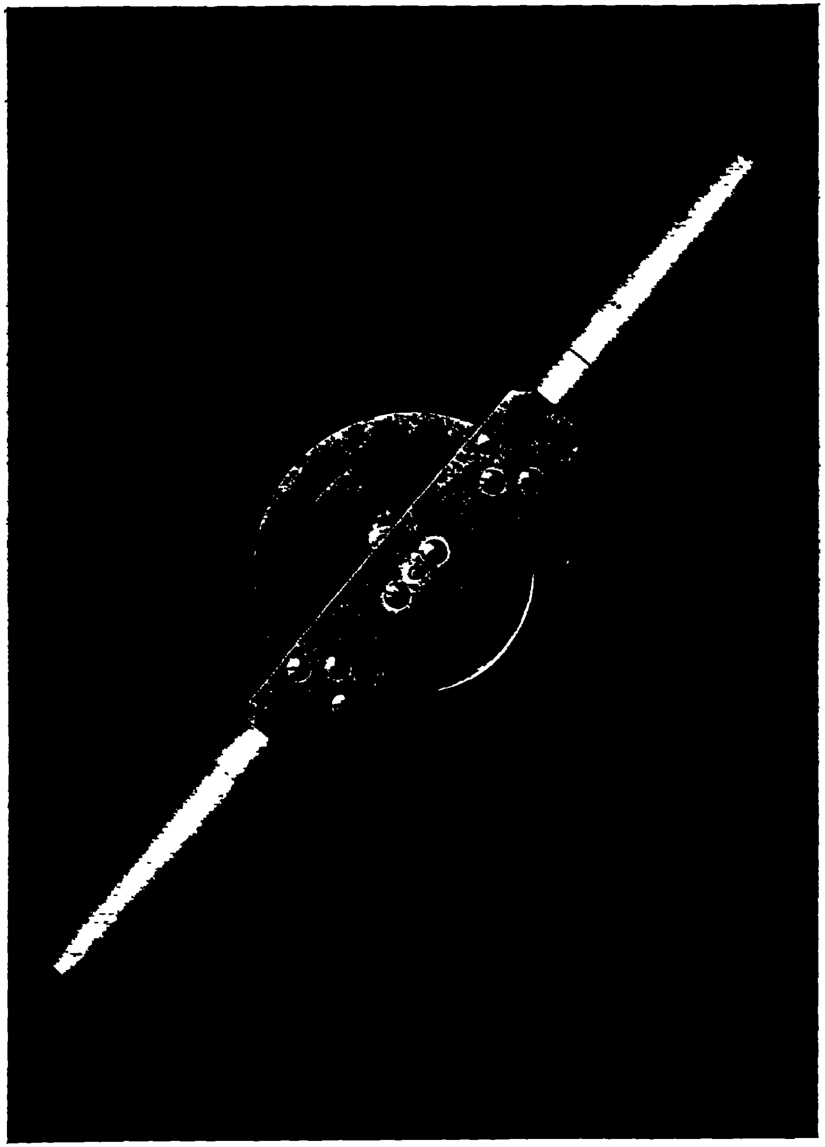
PLATE V.

9 THEODOLITE STAND ON RING.



10. TRANSFERRING APPARATUS.

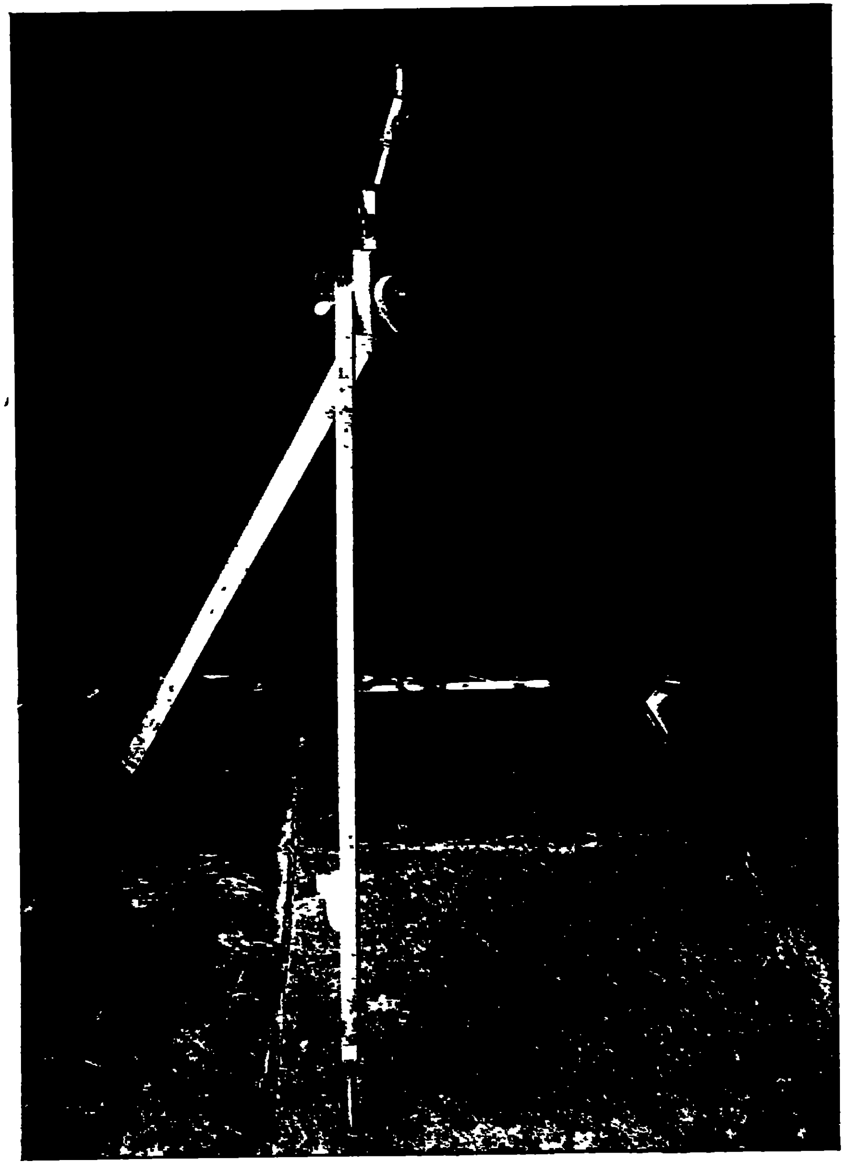
PLATE VI.



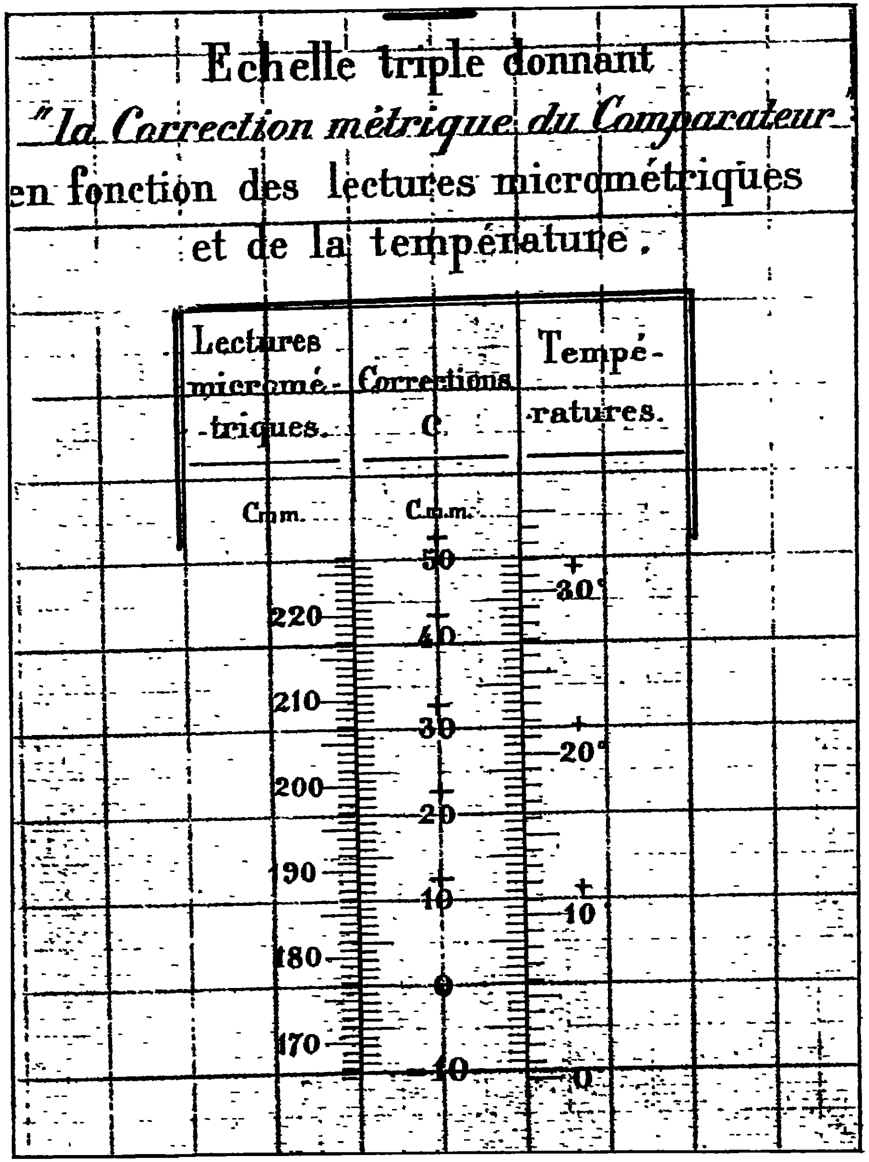
11. PULLEY WHEEL OF STRAINING POLE.

12. STRAINING POLE AND WEIGHT SUSPENDED.

PLATE VII.

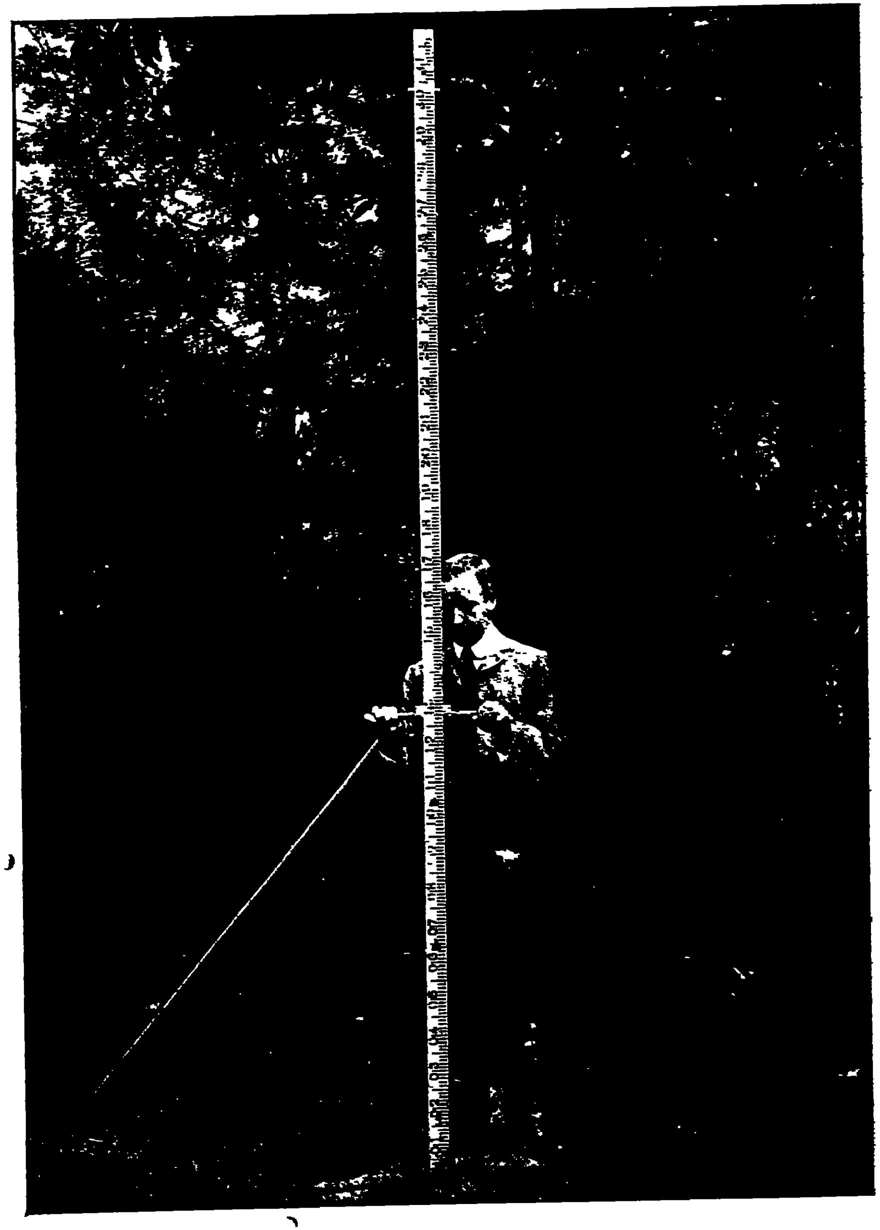


13 TRIPOD OF JADERIN BASE APPARATUS.



14. TEMPERATURE SCALE FOR STANDARDISER.

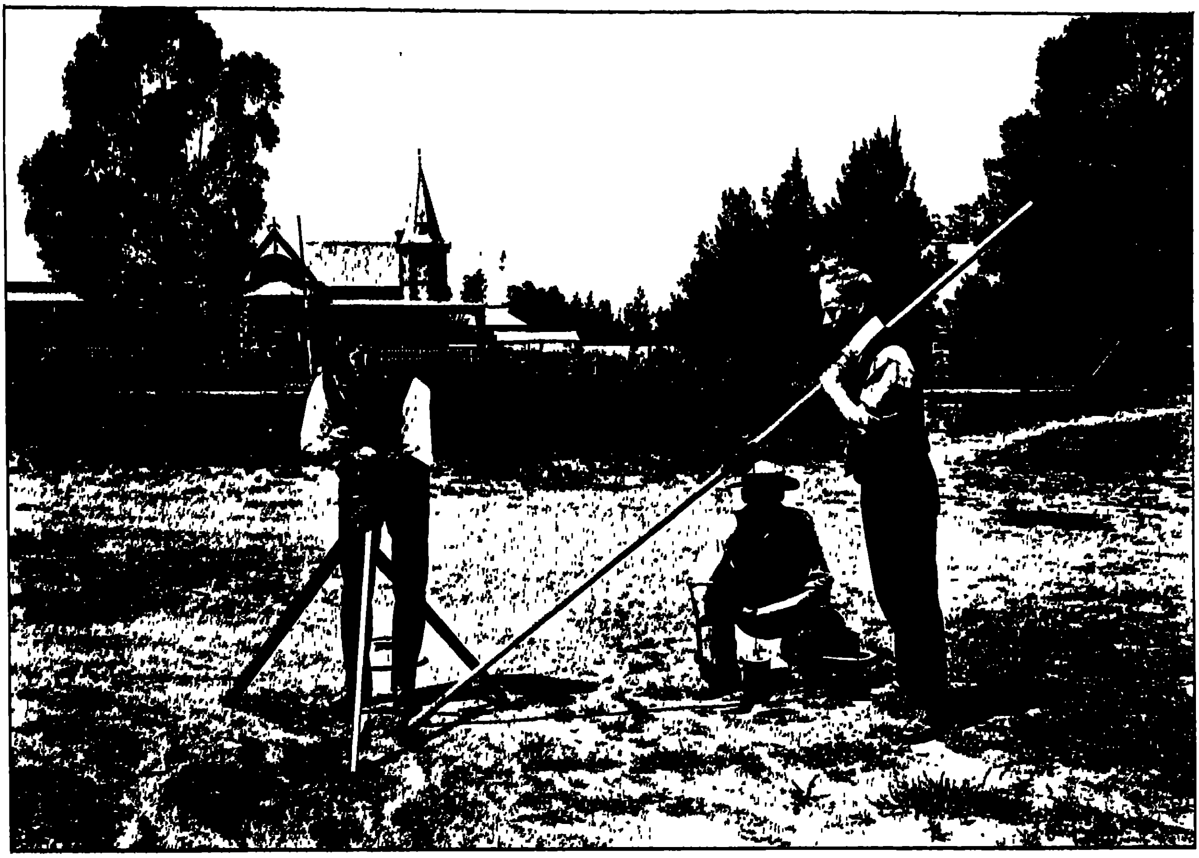
PLATE VIII.



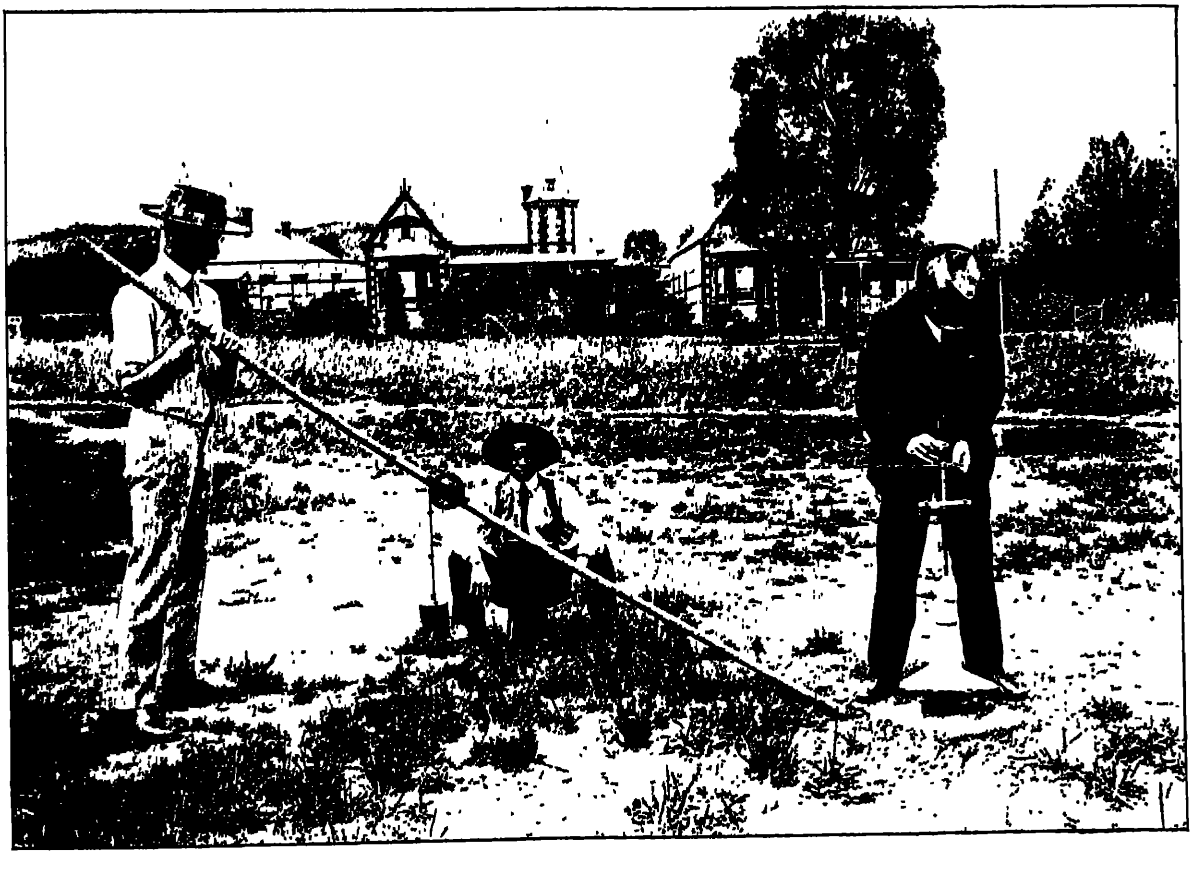
15. METHOD OF HOLDING LEVELLING STAFF IN THE FIELD.

16. DRUMS FOR CONCRETE BEACONS.

PLATE IX.



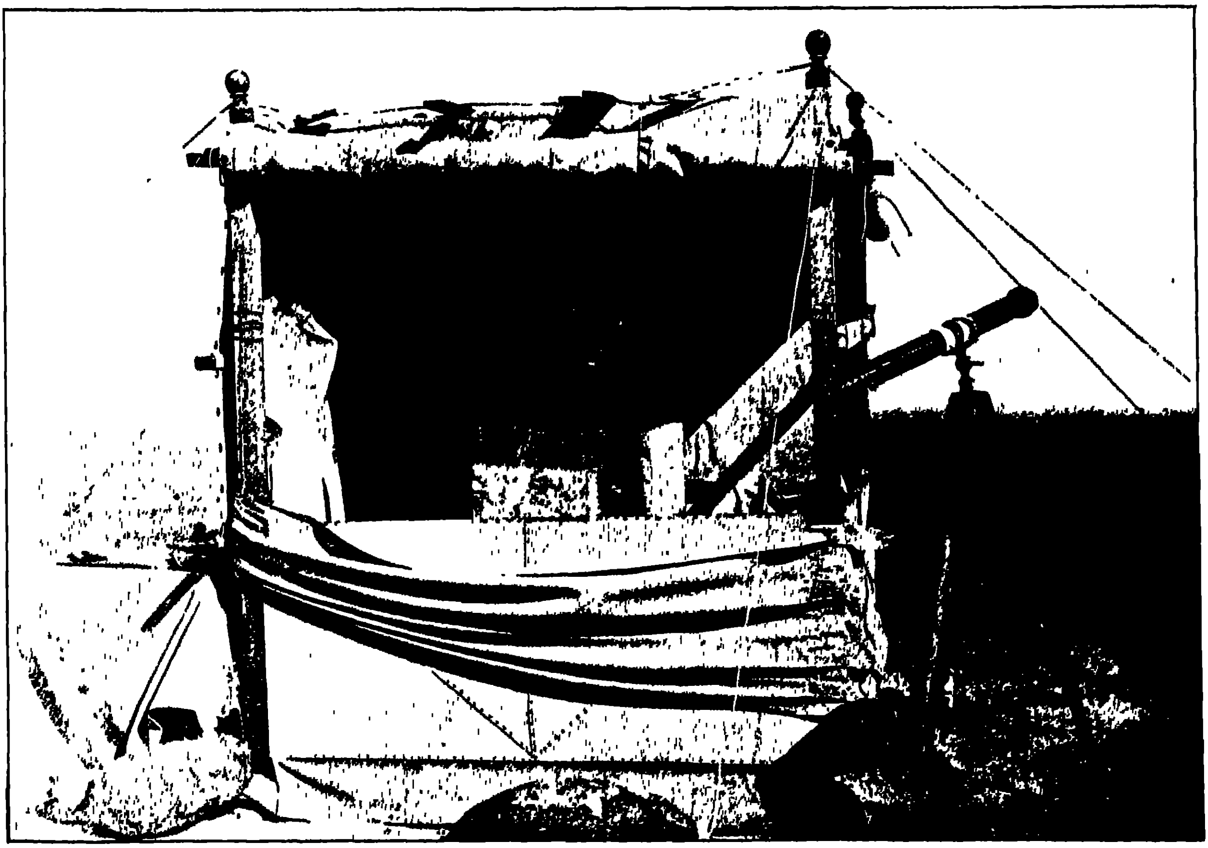
17. PRECEDING TERMINAL OF JADERIN WIRE, WITH OBSERVERS.



18. FOLLOWING TERMINAL OF JADERIN WIRE, WITH OBSERVERS.

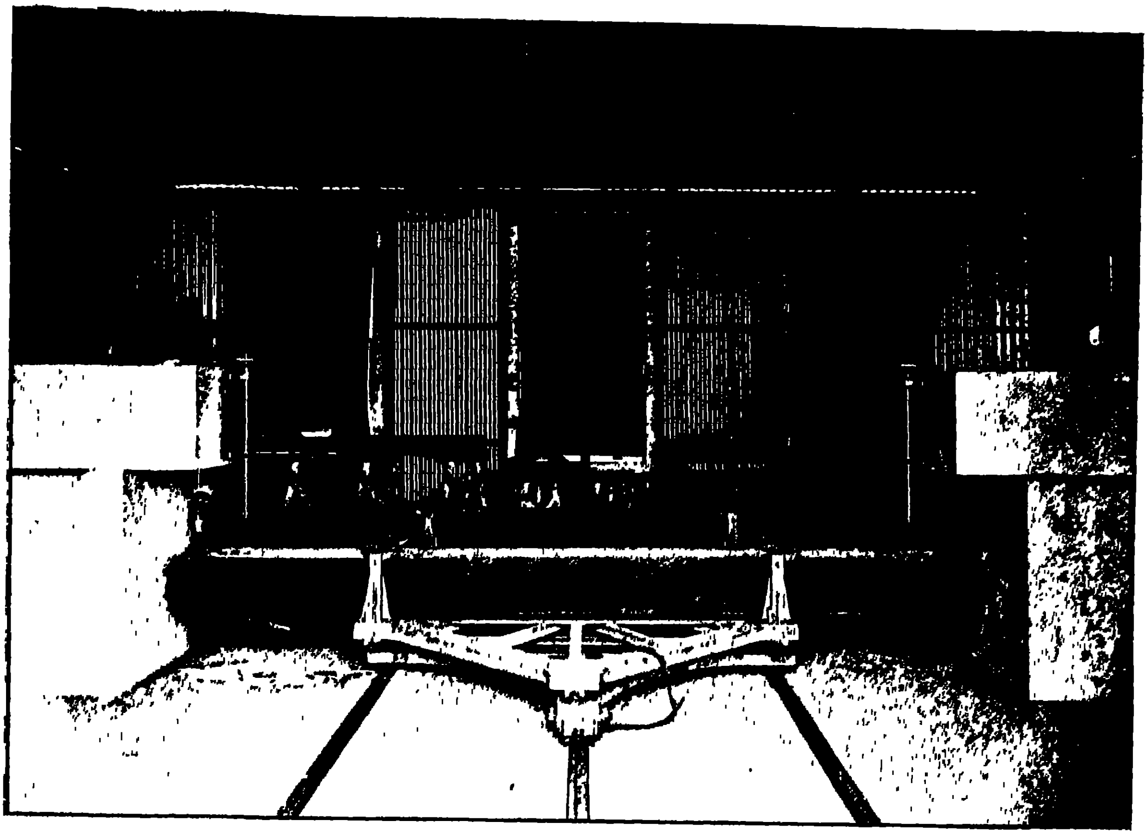
PLATE X.

19. JADERIN WIRES, WORKING WITH, IN THE FIELD.

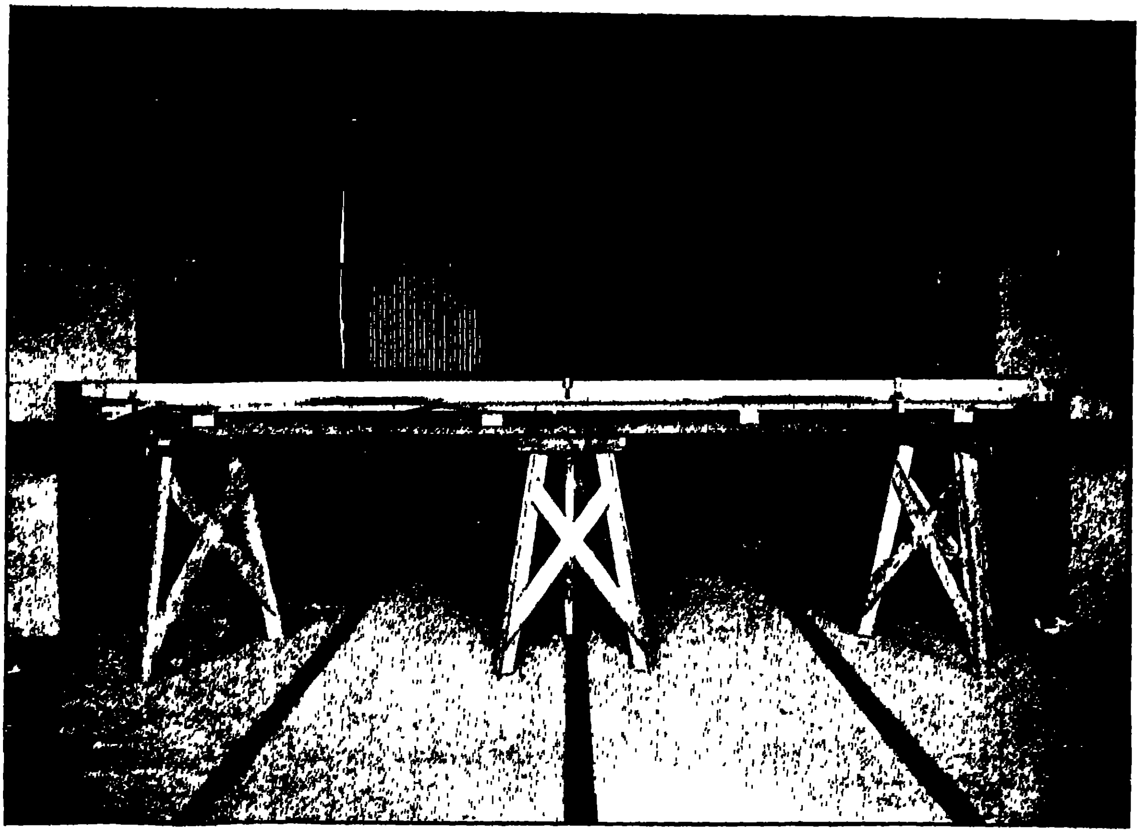


20. REPSOLD THEODOLITE ON CONCRETE PILLAR IN HUT, SHOWING ARRANGEMENT OF BULLSEYE LANTERNS FOR ASTRONOMICAL OBSERVATIONS.

PLATE XI.

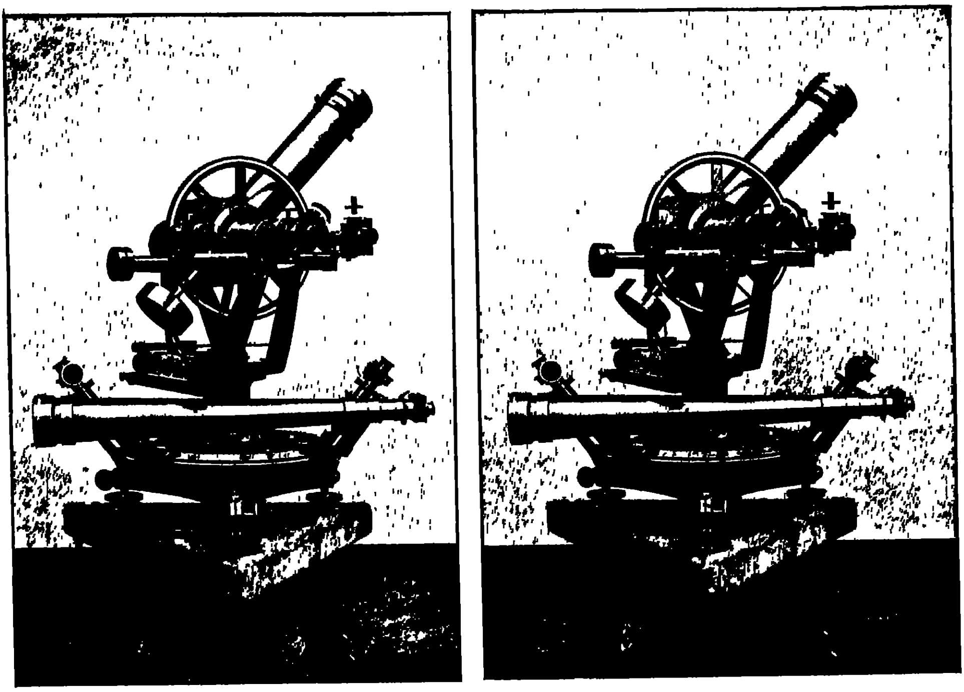


21. BAR COMPARISON APPARATUS IN HUT.

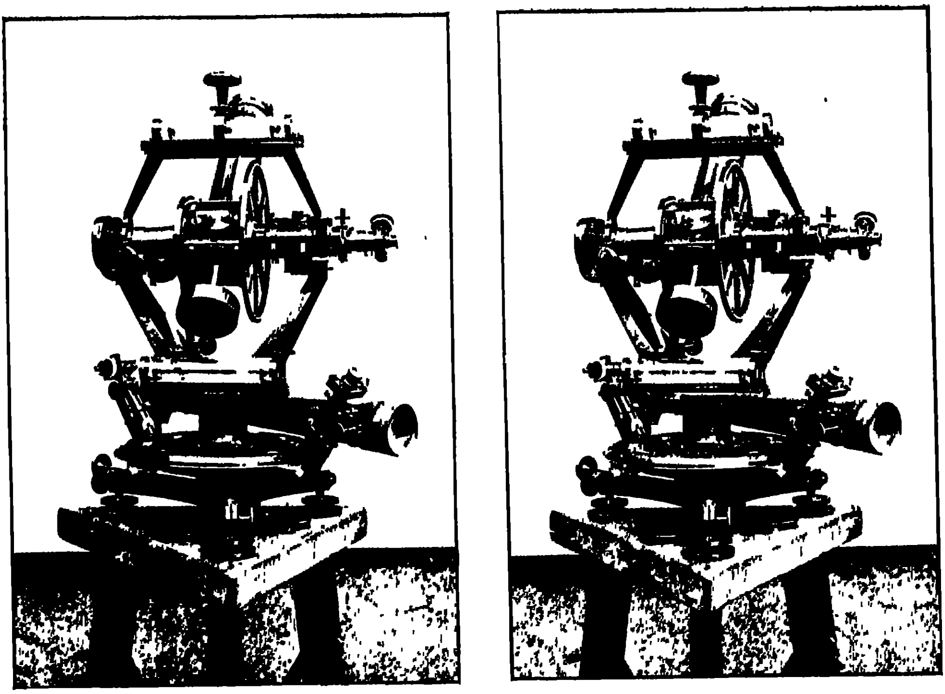


22. STANDARDISER FOR LEVELLING STAVES.

PLATE XII.

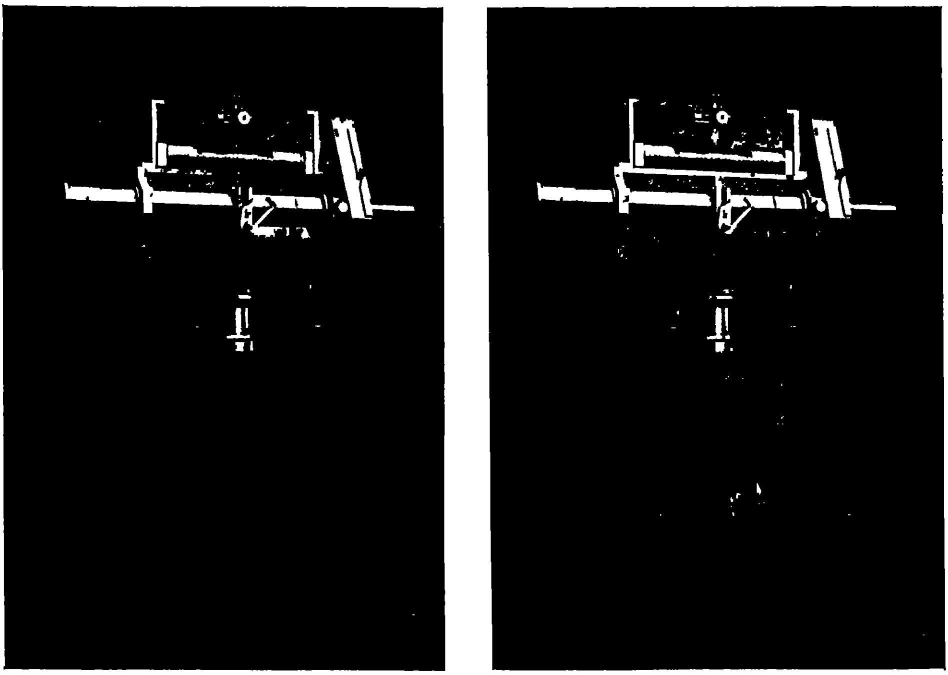


23. STEREOSCOPIC VIEW OF REPSOLD THEODOLITE.

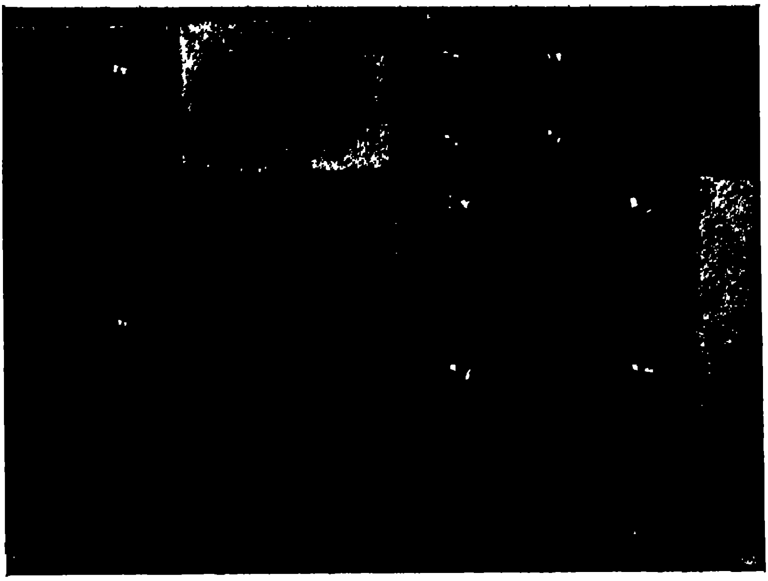


24. DITTO (OTHER SIDE).

PLATE XIII.



25. STEREOSCOPIC VIEW OF LEVELLING INSTRUMENT.



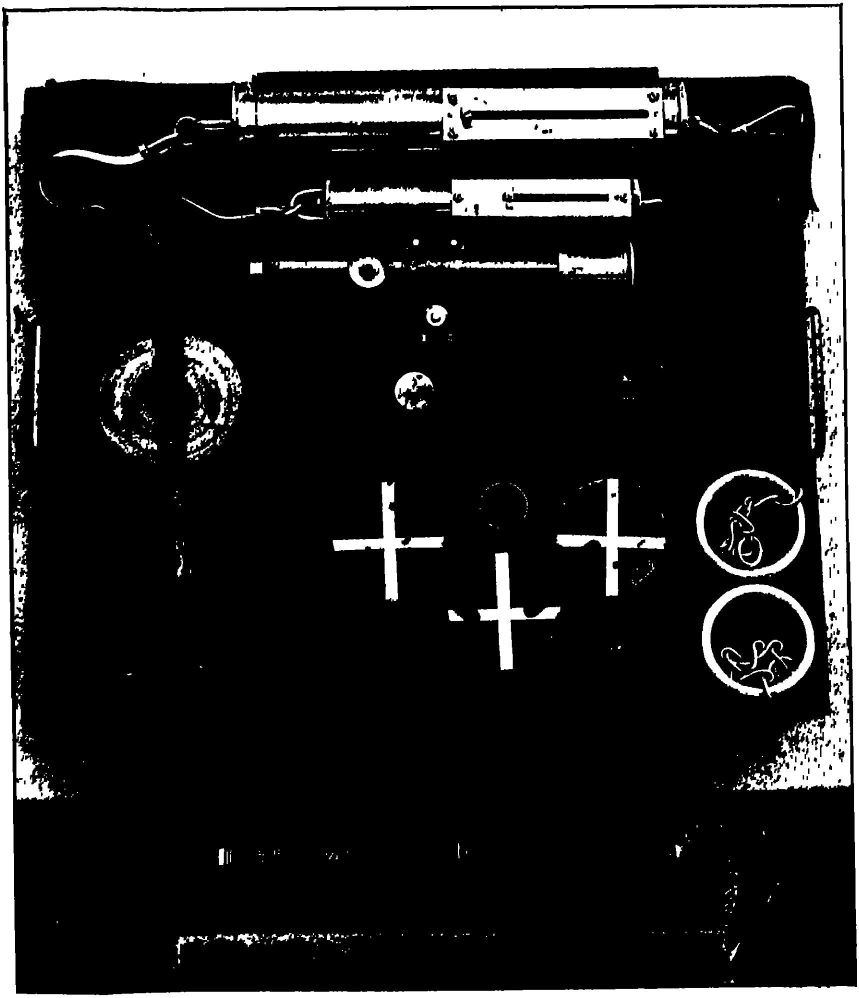
26. TERMINAL OF STANDARDISER OF LEVELLING STAVES, WHERE BRASS AND STEEL RODS HAVE FREE EXPANSION OR CONTRACTION.

PLATE XIV.

27. MICROMETER TERMINAL OF STANDARDISER OF LEVELLING STAVES.

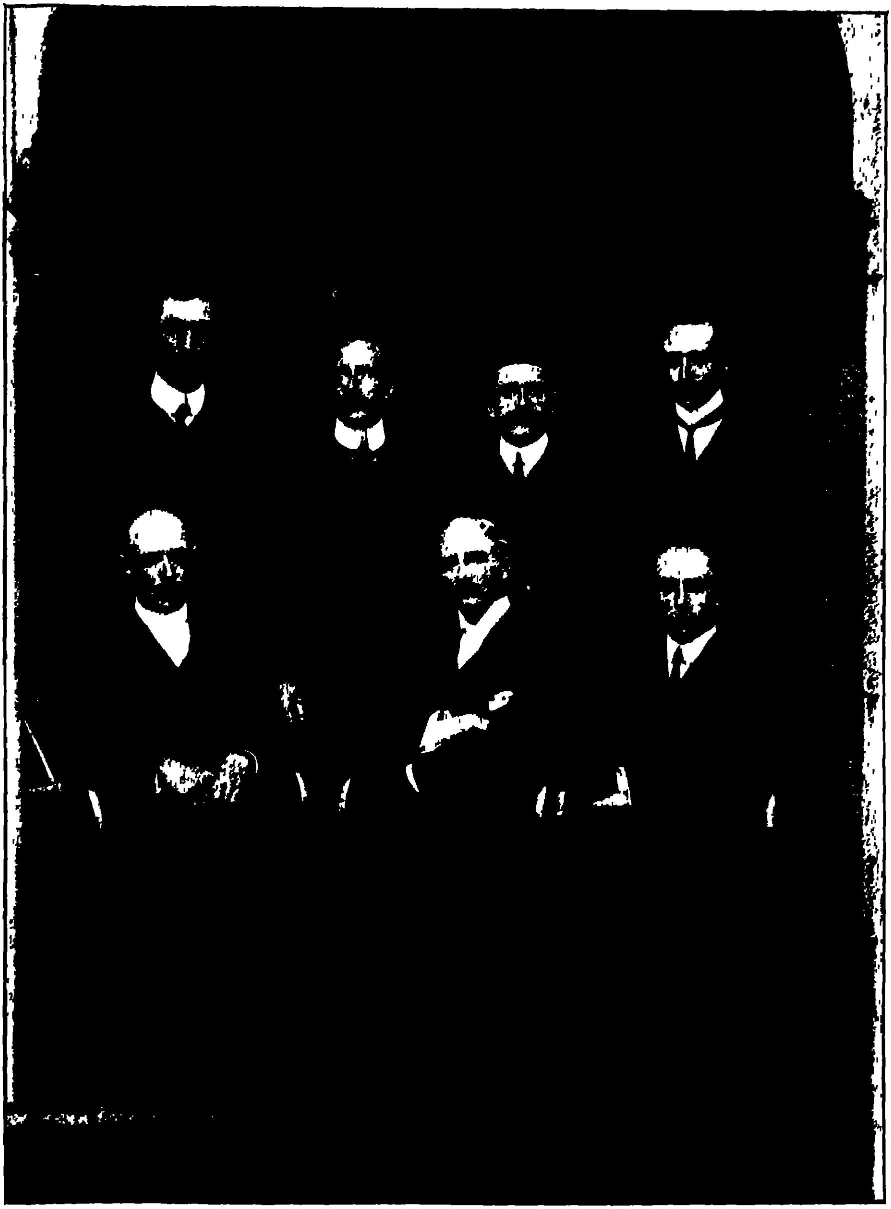
28. "COUDÉ" MICROSCOPE OF STANDARDISER IN POSITION.

PLATE XV.



29. INSTRUMENTAL DETAILS OF JADERIN APPARATUS.

PLATE XVI.



30. PHOTOGRAPH OF THE SURVEY STAFF.

Standing (from left)—Messrs. W. A. Gummer, A. Cochrane, E. H. Banks, S. B. Morgenrood.
Sitting (from left)—Mr. W. B. Robinson, Col. W. G. Morris, P. C. Morgenrood.